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Studies on the Rocky Mountain flora — XXIX

PER AXEL RYDBERG

MONOTROPACEAE

Hypopitys latisquama Rydb. sp. nov.

Plant pink, 1–3 dm. high, more or less short-pubescent above; scales of the stem broadly ovate, obtuse, 1–1.5 cm. long; flowers usually 10–15; sepals spatulate or cuneate, 8–10 mm. long, abruptly acuminate, ciliate; petals cunate or obovate, 11–12 mm. long, rounded and sinuate at the apex, pubescent and ciliate, filaments and style copiously hairy; stigma retrorsely bearded.

This is closely related to *H. lanulosa* (Michx.) Nutt., but differs in the large and broad scales on the stem and the larger flowers.

MONTANA: Bridger Mountains, July 28, 1896. *Flodman 708* (type, in herb. N. Y. Bot. Gard.).

WYOMING: 1873, *Parry 196*.

WASHINGTON: Olympic Mountains, *Elmer 2464*.

PRIMULACEAE

Primula specuicola Rydb. sp. nov.

Perennial with a short rootstock; leaves 5–13 cm. long, thin, slightly farinose when young, in age glabrate, with winged petioles; blades spatulate or elliptic, obtuse at the apex, sinuate-dentate; scape 1–1.5 cm. long; umbels 10–20-flowered; bracts linear-subulate, thin, 5–10 mm. long, slightly gibbous at the base; pedicels 5–10 mm. long in flower or 1–4 cm. long in fruit; calyx densely farinose; tube deeply campanulate, 3–5 mm. long; lobes linear-oblong, 2.5–3.5 mm. long, obtusish; corolla-tube yellowish, 8–10

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mm. long, 1.5 mm. in diameter; lobes cuneate, merely emarginate with a broad sinus, dark violet, about 3 mm. long; stamens inserted in the middle of the corolla-tube; capsule about 6 mm. long.

This species is related to *P. farinosa* L. and *P. incana* M. E. Jones, but differs from both in its very thin leaves, more exserted corolla-tube and slender bracts. In *P. incana* M. E. Jones (*P. americana* Rydb.), the only other species of the group in the Rocky Mountains, the bracts are thick, almost fleshy, obtusish, lanceolate, and often nearly equaling the pedicels. In the bracts and inflorescence, it resembles more *P. farinosa* L. of Europe and northeastern America. *P. Ellisiae* of the Sandea Mountains of New Mexico, though belonging to this group and of the same habit, has much larger flowers, the lobes of the corolla being 8–10 mm. long. *P. specuicola* grows only in loose soil, under overhanging cliffs in the alcove-like heads of the canyons, characteristic of the limestone bluffs of San Juan River.

UTAH: Along San Juan River, near Bluffs, Aug. 25–29, 1911, *Rydberg 9882* (type, in herb. N. Y. Bot. Gard.); same locality, Feb., 1912, *Edna Scorup*, and in 1895, *Alice Eastwood*.

Androsace albertina Rydb. sp. nov.

Cespitose perennial, but scarcely pulvinate; leaves narrowly oblanceolate, about 1 cm. long, sparingly ciliate, not carinate; scape 5–10 cm. long, slender, sparingly hairy; bracts linear-lanceolate, 3–4 mm. long; pedicels 3–5 mm.; calyx-lobes elliptic, obtuse; corolla-lobes 2–3 mm. long.

This is most like the European *A. Chamaejasme* Host, but the leaves and bracts are narrower. It differs from *A. carinata* Torr. in the narrower leaves, not carinate beneath, less pulvinate habit, longer peduncles, longer pedicels, and smaller flowers.

ALBERTA: Lake Agnes, National Park, Banff, Aug. 1897, *Mr. and Mrs. C. Van Brunt 77* (type, in herb. N. Y. Bot. Gard.); Jumping Pound Creek, June 14, 1897, *Macoun 23478;* Rocky Mountains 1858, *Bourgeau*.

MONTANA: Yellow Mountain, June 24, 1897, *R. S. Williams*.

Androsace simplex Rydb. sp. nov.

Annual; leaves oblanceolate, 3–6 mm. long, acute, entire, minutely puberulent; scape usually solitary, erect, very slender, 2–7 cm. high; bracts oval or lance-oval, 2–4 mm. long; pedicels

5–15 mm. long, suberect or strongly ascending; calyx-tube obpyramidal, about 2 mm. long; lobes lanceolate, about 1.5 mm. long, acute; corolla small, shorter than the calyx.

This is related to *A. occidentalis*, but the plant is more delicate, the scapes solitary, bearing a 1–4-flowered umbel with strongly ascending or nearly erect pedicels, the bracts smaller and distinctly acute.

MONTANA: Missoula, May, 1897, *Elrod & assistants 33* (type, in herb. N. Y. Bot. Gard.).

UTAH: Near Salt Lake City, May 1882, *M. E. Jones.*

BRITISH COLUMBIA: Lytton, April 17, 1889, *Macoun.*

Dr. Greene separates an American species *Androsace capillaris* Greene from the Asiatic *A. filiformis* Retz, and claims that the former is a perennial. All American specimens that I have seen are, however, annuals, and I can see no reason for such a separation.

Dodecatheon Jaffreyi Moore has been collected near Sawtooth, Idaho, by Evermann.

GENTIANACEAE

Anthopogon ventricosum (Griseb.) Rydb.

Gentiana ventricosa Griseb. in Hook. Fl. Bor.-Am. 2: 65. 1838.

Anthopogon Macounii (Holm) Rydb.

Gentiana Macounii Holm, Ottawa Nat. 15: 110, 179. 1901.

Anthopogon tonsum (Lunell) Rydb. sp. nov.

Gentiana detonsa tonsa Lunell, Bull. Leeds Herb. 2: 7. 1908.

This is closely related to *A. Macounii* (Holm) Rydb., but differs in the glabrous filaments, a character not pointed out by Dr. Lunell.

Amarella tortuosa (M. E. Jones) Rydb.

Gentiana tortuosa M. E. Jones, Proc. Calif. Acad. II. 5: 707. 1895.

Amarella ventorum Rydb. sp. nov.

Gentiana arctophila densiflora Torr. Fremont's Rep. 94. 1845.

Not *G. arctophila densiflora* Griseb.

Low annual or biennial, branched near the base; stems 5–10 cm. long, branched, internodes shorter than the leaves; basal

leaves oblanceolate; stem-leaves linear or linear-lanceolate, about 2 cm., acute; flowers 1–3 in the axils; pedicels 2–8 mm. long; calyx-tube about 2 mm. long; lobes linear-lanceolate, 3–5 mm. long, acute, scabrous on the margins; corolla about 5 mm. long; lobes ovate, obtuse or acute; crown none.

This little *Amarella* lacks the setaceous fimbriate crown at the base of the corolla-lobes and therefore should be classified with the arctic or subarctic *A. propinqua* (Richards.) Greene, and *A. arctophila* (Griseb.) Greene, but the corolla-lobes are acute or obtuse, instead of cuspidate.

WYOMING: Wind River Moutainns, Aug. 4, 1843, *Fremont.*

Dasystephana oregana (Engelm.) Rydb.

Gentiana oregana Engelm.; A. Gray, Syn. Fl. 2[1]: 122. 1878.

Dasystephana glauca (Pall.) Rydb.

Gentiana glauca Pall. Fl. Ross. 2: 104. 1784.

Dasystephana calycosa (Griseb.) Rydb.

Gentiana calycosa Griseb. Gen. et Sp. Gent. 292. 1839.

Dasystephana monticola Rydb. sp. nov.

Gentiana calycosa stricta Griseb. Gen. et Sp. Gent. 292. 1839.

Gentiana calycosa monticola Rydb. Bull. Torrey Club 24: 252. 1897.

Dasystephana obtusiloba Rydb. sp. nov.

Cespitose perennial; stems erect or ascending, about 1 dm. high; internodes short, equaling or a little longer than the leaves; leaves very broadly ovate, 3–5-ribbed, usually acute at the apex and subcordate at the base; calyx-tube broadly turbinate, 5–6 mm. long; lobes broadly oval, rounded at the apex, often overlapping, about 8 mm. long; corolla dark blue, about 3.5 cm. long; lobes rounded at the apex; lobes of the plaits about half as long as the corolla lobes.

This is related to *D. calycosa*, but differs in the lower habit and rounded corolla-lobes.

MONTANA: Mary Baker Lake and Sperry Glacier, Aug. 21, 1901, *Vreeland 1162* (type, in herb. N. Y. Bot. Gard.); Lake MacDonald, Aug. 22, 1901, *Umbach 371;* Mount MacDonald, July 25, 1900, *Elrod & assistants;* Silloway Peak, July 17–19, 1901, *MacDougal 692;* Blackfoot Indian Reservation, Aug. and Sept. 1909, *Gilman Thompson.*

Swertia Fritillaria Rydb.

Glabrous, light green, perennial; stem 1.5–3 dm. high; basal leaves and lower stem-leaves alternate, 6–10 cm. long, thin, long-petioled; blades obovate, spatulate, rounded at the apex, abruptly contracted into winged petioles of about the same length; middle and upper stem-leaves all alternate or a single pair of opposite ones, oblanceolate or oblong; inflorescence rather lax, elongate; pedicels 1–2 cm. long; sepals lanceolate, about 6 mm. long; corolla-lobes lanceolate, mostly acute, greenish white along the midrib and azure along the margins, dotted all over with dark blue spots in the manner of many species of *Fritillaria;* filaments more or less dilated, some of them very broad; glands inconspicuous with rather long blue fringes.

UTAH: Wet places in caynons: Big Cottonwood Canyon, August 4, 1905, *Garrett 1566* (type, in herb. N. Y. Bot. Gard.).

APOCYNACEAE

Amsonia Eastwoodiana Rydb. sp. nov.

Perennial, with a short woody base; stem 3–5 dm. high, glabrous; stem-leaves lanceolate, usually narrowly so, 3–5 cm. long, glabrous, acute at each end; leaves of the numerous strongly ascending branches linear; calyx-lobes subulate, 2 mm. long or longer; corolla 16–20 mm. long; tube narrowly trumpet-shaped; lobes nearly 4 mm. long; pod 5–8 cm. long, about 8 mm. thick, constricted and often breaking off between the seeds, 3–5-seeded; seeds oblong, about 1 cm. long and 6 mm. thick.

This is most closely related to *A. brevifolia*, having the same flower and fruit, but the plant is in habit more like *A. Fremontii*, for which it has been mistaken. The latter has still longer calyx-lobes which are narrower, and its pod is not restricted between the seeds. In canyons of desert regions.

UTAH: Moab, July, 1911, *Rydberg & Garrett 8468* (fruit, type, in herb. N. Y. Bot. Gard.); Willow Creek Canyon, August, 1895, *Alice Eastwood 73* (fruit).

ARIZONA: Ten miles east of Holbrook, June 22, 1901, *L. F. Ward* (flowers); Lee's Ferry, 1890, *M. E. Jones.*

Amsonia texana (A. Gray) Heller of the Flora of Colorado and Coulter & Nelson's Manual is *A. latifolia* Jones. *A. brevifolia* A. Gray, and *A. tomentosa* Torr. have been collected in southern Utah.

ASCLEPIADACEAE

Astephanus utahensis Engelm., *Philibertella cynanchoides* (Dec.) Vail and *P. heterophylla* (Engelm.) Vail, *Asclepias erosa* Torr., *A. macrosperma* Eastw. and *A. labriformis* Jones have been collected in Utah; *Acerates lanuginosa* (Nutt.) DC., in the Yellowstone Park; *Asclepias ovatifolia*, in Saskatchewan; and *Asclepias mexicana* Cav., in Idaho.

CONVOLVULACEAE

Cressa erecta Rydb. sp. nov.

Stem branched, with a woody base, erect, 2–3 dm. high with erect branches, silvery canescent; leaves elliptic, 5–7 mm. long, acute at both ends, sessile, silvery canescent; pedicels in fruit 6–10 mm. long, usually exceeding the leaves; bracts elliptic, 3 mm. long; sepals 4–5 mm. long, oval, equaling the corolla-tube; corolla white; lobes elliptic, acutish, rarely spreading; filaments filiform, slightly pubescent; ovary densely pubescent; styles filiform.

This differs from *C. depressa* Goodding in the erect stem and branches, the more silvery pubescence, the longer pedicels (in *C. depressa* shorter than the leaves) and the comparatively narrower corolla-lobes.

UTAH: Near Beck's Hot Springs, Salt Lake County, July, 1905, *Garrett 870f* (type, in herb. N. Y. Bot. Gard.).

CUSCUTACEAE

Cuscuta curta (Engelm.) Rydb. sp. nov.

Cuscuta Gronovii curta Engelm. Trans. St. Louis Acad. 1: 507. 1859.

In saline districts of Utah and Colorado.

POLEMONIACEAE

Dr. Brand* reduces the amply distinct *Phlox muscoides* Nutt. to

* Pflanzenreich, Vol. 4, Fam. 250. The following pages contain a good deal of criticism of Dr. Brand's monograph of this family. The monograph is one of the best, differing in that respect from most works done by Europeans on American plants. The citation of publication is very carefully prepared, correct, and complete; but Dr. Brand has fallen into the same errors as most foreigners do, in not trying to find out exactly what the types are or what plants the descriptions really represent. He made definite pronunciations as to species he had never seen, and made synonyms from mere guesses. My criticisms are limited to the Rocky Mountain species. If the Pacific Slope species are considered, probably as many more incongruities could be pointed out.

a subspecies of *P. caespitosa* and makes *P. Covillei* E. Nels. and *P. condensata* (Gray) E. Nels. varieties of this subspecies. It is evident that Dr. Brand does not know what *P. muscoides* is; for the only Montana specimen he cites is *Rydberg & Bessey 4815*, which belongs to *Phlox caespitosa* and is so referred in my Flora of Montana. He also cites two specimens from California, *Coville 2072* from Mount Whitney and *Hildebrand* from Silver Mountains and also one from Charleston Mountains, Nevada, *Purpus 6111*. *Phlox muscoides* Nutt. is unknown to both California and Nevada. Neither *P. Covillei* nor *P. condensata* is closely related to *P. muscoides*. The relationship of *P. muscoides* is with *P. bryoides* on one hand, and *P. Hoodii* on the other; and the calyx is arachnoid-villous, not glandular as in *P. caespitosa*.

Dr. Brand made *Phlox albomarginata* M. E. Jones, *P. costata* Rydb., *P. collina* Rydb. and *P. diapensioides* Rydb. varieties of *P. Kelseyi*, while he kept *P. alyssifolia* Greene as distinct and described a new species, *P. variabilis*, from material which I had included in *P. collina*. It is evident that Dr. Brand did not know the plants he was so treating. Under his var. *albomarginata* he gives the following distribution:

"Montana (nach Jones)—Wyoming: Cooper Creek (Nelson n. 4336)."

Evidently he had not seen Jones's specimens and *Nelson 4336* is typical *P. Kelseyi*, and has nothing of the habit of *P. albomarginata*.

Under each of his var. *collina* and var. *diapensioides* he gives the following: "Montana (nach Rydberg)." In other words, he had seen no specimens. Under his var. *costata* he gives: "Montana: Madison Co. (Nelson 5148)." This number is not found in the herbarium of the New York Botanical Garden, but judging from the rest I am inclined to think that this determination is just as unreliable. It may be that *5148* is a misprint for *5418*, which is labeled *Phlox Kelseyi*, and should be referred to it, but is not typical. It has nothing to do with *P. costata*. Furthermore, *P. costata* is not closely related to *P. Kelseyi*, but intermediate between *P. multiflora* A. Nels. and *P. glabrata* (A. Nels.) Brand, but with a densely pubescent calyx.

In my opinion, *P. alyssoides* Greene, *P. collina* Rydb., and *P.*

variabilis Brand are one and the same species. I included *Hall & Harbour 454* in the original description of *P. collina*, and I have no reason for changing my opinion. There is no essential difference between my diagnosis of *P. collina* and Brand's characterization of *P. variabilis*, except that I described the leaves as "oblong or ovate" and Brand gives them as "linear." The specimens in the Columbia University herbarium of *Hall & Harbour 454* have oblong leaves, hence agreeing better with my description. Furthermore, *P. alyssoides* (= *P. collina*), as I understand it, has been collected at several places in both Utah and Wyoming, and why not also in Colorado? Professor A. Nelson in Coulter & Nelson's New Manual has followed Dr. Brand's treatment of this group very closely. It would have been much better for him to find out the real facts.

Brand's description of *P. Douglasii* is not correct; he describes the calyx as eglandulose-pilose, while the duplicate of the type in the Columbia University herbarium is densely glandular.

Phlox dasyphylla Brand is not better than *P. variabilis*, being only a small-flowered and narrow-leaved form of *P. multiflora*, not uncommon in Colorado and Wyoming.

Phlox densa Brand is a low condensed from of *P. austromontana*, more like the type than *Phlox austromontana prostrata* E. Nels., which Dr. Brand regards as a mere variety. The only one of Dr. Brand's new species from the Rockies that I regard as good is *P. glabrata* (E. Nels.) Brand (*P. Hoodii glabrata* E. Nels.).

In describing *Phlox aculeata** Prof. A. Nelson compares it with the *P. caespitosa* group. The intercostal portion of the calyx is replicate, however, which would associate it with *P. Stansburyi*. I can not distinguish it from *P. viridis* E. Nels.

Dr. Brand's conception of *Gilia congesta* Hooker is entirely wrong. He regards *G. iberidifolia* Benth. as the typical *G. congesta*. A duplicate of Douglas's plant is found in the Columbia University herbarium, and a closer study of the same shows that it is the same as Jenney's plant from the Black Hills, which constituted a part of *G. spicata capitata* A. Gray, and my number *886*, also from the Black Hills. These two specimens I included in my *G. cephaloidea*. Unfortunately I did not designate a type and some botanists might claim that Jenney's plant which was first

* Bot. Gaz. **52**: 270. 1911.

mentioned should be regarded as such. The short characterization was, however, drawn principally from my number *2763* from Lima, Montana, and this is marked in our herbarium as the type. Since more specimens have been seen, both of the Montana plant and of that from the Black Hills, it has become evident that they are not exactly the same. As the Montana plant is marked as the type, I now limit my *G. cephaloidea* to it. If Jenney's plant or my *886* were to be regarded as the type of *G. cephaloidea*, this would become a synonym of *G. congesta* and the Montana plant should have a new name. As it is, the *G. cephaloidea* of Brand's monograph should become *G. congesta* Hooker, and Brand's *G. congesta* is *G. iberidifolia* Benth.

Brand divides the *Gilia spicata* group in two divisions: one containing *G. spicata*, *G. globularis* and *G. trifida*, with the corolla-lobes (in dry state) dark purple; and *G. cephaloidea* and *G. congesta*, with lobes of the corolla (in dry state) whitish. The dark purple color is simply due to poor drying. Dr. Brand also describes the corollas of *G. spicata* as purple. In fact they are greenish white. We have specimens of *G. spicata* which still retain the greenish white color. Such a distinction is scarcely scientific.

Under *Gilia congesta iberidifolia*, Dr. Brand gives as synonyms *G. spergulifolia* Rydb. and *G. roseata* Rydb. Evidently Dr. Brand had not seen a specimen of *G. roseata*. This is perhaps closer related to his own *G. globularis* than to *G. iberidifolia*, except that the stems are branched and bear several heads. He had seen a specimen of *Baker 534*, which I referred to *G. spergulifolia*. When doing so I had in mind only the specimen in the herbarium of the New York Botanical Garden. I do not know by what this number may be represented elsewhere. However, I can not distinguish this from *Nelson 5430*, which Dr. Brand refers to the var. *crebrifolia*, evidently not knowing that the var. *Merrillii* (*G. Merrillii* A. Nels.) is the original *G. crebrifolia* Nutt. A duplicate of the type is in the Columbia University herbarium. The synonomy of this group of Gilias is therefore very mixed. In order to straighten out the matter I give the following synonymy:

GILIA SPICATA Nutt. Jour. Acad. Nat. Sci. Phila. II. 1: 156. 1848.

GILIA GLOBULARIS Brand, Pflanzenreich 4^{250}: 120. 1907.

Gilia spicata capitata A. Gray, Proc. Am. Acad. **8**: 274 (as to type). 1870.

Gilia cephaloidea Rydb. Fl. Colo. 277, in part. 1906.

GILIA CEPHALOIDEA Rydb. Bull. Torrey Club **24**: 293 (as to the Montana plant). 1897.

GILIA CONGESTA Hook. Fl. Bor.-Am. **2**: 75. 1838.

Gilia spicata capitata A. Gray, Syn. Fl. 2^1: 144, in part. 1878.

Gilia cephaloidea Rydb. Bull. Torrey Club **24**: 293, in part. 1897.—Brand, Pflanzenreich 4^{250}: 121. 1907.

GILIA IBERIDIFOLIA Benth. in Hook. Jour. Bot. & Kew Misc. **3**: 290. 1851.

Gilia congesta iberidifolia Brand, Pflanzenreich 4^{250}: 121. 1907.

Gilia nuda (Eastw.) Rydb.

Gilia congesta nuda Eastw. Proc. Calif. Acad. II. **6**: 308. 1896.

GILIA ROSEATA Rydb. Bull. Torrey Club **31**: 633. 1904.

GILIA SPERGULIFOLIA Rydb. Bull. Torrey Club. **31**: 633. 1904.

Gilia congesta crebrifolia S. Wats. Bot. King Exped. 5: 268, in part. 1871.

Gilia congesta iberidifolia crebrifolia Brand, Pflanzenreich 4^{250}: 121. 1907.

GILIA CREBRIFOLIA Nutt. Jour. Acad. Nat. Sci. Phila. II. **1**: 156. 1848.

Gilia congesta crebrifolia A. Gray, Proc. Am. Acad. **8**: 273. 1870.

Gilia Merrillii A. Nels. Bot. Gaz. **34**: 27. 1902.

Gilia congesta iberidifolia Merrillii Brand, Pflanzenreich 4^{250}: 122. 1907.

GILIA BURLEYANA A. Nels. Bot. Gaz. **54**: 144. 1912.

This species also belongs to this group. Prof. Nelson stated in the original description: "Until now this section contained no perennials." Both *G. iberidifolia* and *G. roseata* are perennials. Gray divides the group in "annuals and short lived perennials or biennials."

Gilia palmifrons (Brand) Rydb. sp. nov.

Gilia congesta palmifrons Brand, Pflanzenreich 4^{250}: 122. 1907.

I think also that Dr. Brand has misidentified *Gilia trifida* Nutt.

Dr. Brand evidently drew his description from *Jones 5949*, the only specimen he cited. He described the stamens as being inserted in the middle of the corolla-tube, while Nuttall described them as inserted in the throat. I have not seen Nuttall's type, but I have collected in the region of the type locality, Scott's Bluffs, Nebraska. The only species growing there are *G. spicata* and *G. iberidifolia*. I believe that Dr. Gray interpreted *G. trifida* Nutt. correctly as a depauperate form of *G. spicata*. If this is correct, Brand's *G. trifida* must receive a new name.

Gilia frutescens Rydb. sp. nov.

Fruticose, perennial; stems woody below, branched above, 3–5 dm. high; herbaceous branches 2–3 dm., sparingly pubescent; leaves linear, glabrous or nearly so, simple, 2–5 cm. long, 1–2 mm. wide, callous-tipped; flowers capitate at the ends of the branches; calyx crisp-hairy; teeth lanceolate, cuspidate, shorter than the tube; corolla white, 5–6 mm. long, salvershaped; tube barely exserted; lobes about 2.5 mm. long, oval, acute; stamens inserted in the throat; filaments short; style glabrous, nearly as long as the corolla tube.

The type was labeled *Gilia multiflora*, to which it is not related. It belongs to the *G. iberidifolia* group, and has as entire leaves as *G. spergulifolia* and *G. crebrifolia*, but the habit is different. It differs from all its relatives in the tall shrubby habit. The other species are at most suffruticose and less than 3 dm. high.

UTAH: Springdale, May 14, 1894, *M. E. Jones 5247* (type, in herb. N. Y. Bot. Gard.; duplicate in U. S. Nat. Herb. *no. 326910*).

Dr. Brand has treated the *G. aggregata* group as carelessly as that of the *G. congesta* relatives. It is evident that he has had no specimens of *G. candida* Rydb. and still he makes it *Gilia aggregata* var. *attenuata* forma *candida*, giving *Callisteris leucantha* Greene as another synonym. If he had only read my description, he would not have committed this blunder, for I distinctly pointed out that the lobes of the corolla in *G. candida* are rounded or obtuse at the apex like those of *G. longiflora*. It is a plant with the habit and leaves of *G. aggregata* and the corolla of *G. longiflora*. Both *Callisteris attenuata* and *C. leucantha* have attenuate corolla-lobes and the former is a white-flowered form of *Gilia pulchella* Dougl.,* a species wholly omitted by Dr. Brand. Dr. Brand cited

* Hook. Fl. Bor.-Am. 2: 74. 1838.

two specimens under the forma *candida*, viz. *Nelson 4198* (should have been *4189*) and *Clements 13*. The former is a white-flowered form of *G. pulchella*, the latter belongs to *Gilia scariosa* Rydb. Dr. Brand did not notice the different structure of the calyx, which places *G. scariosa* close to *G. aggregata Bridgesii* A. Gray. Nelson in the New Manual has also confused things. *Gilia scariosa* is made a synonym of *G. aggregata* and *G. candida* of *G. attenuata*. He has also overlooked the characters of the calyx of *G. scariosa* and the rounded corolla-lobes of *G. candida*.

Gilia arizonica (Greene) Rydb.

Callisteris arizonica Greene, Leaflets 1: 160. 1905.
Gilia aggregata typica arizonica Brand, Pflanzenreich 4^{250}: 115. 1907.

Gilia tenuituba Rydb. sp. nov.

Biennial; stem about 3 dm. high, finely glandular-puberulent; leaves pinnatifid with narrowly linear, puberulent, cuspidate divisions; inflorescence a thyrsoid panicle, puberulent; flowers short-pedicelled; calyx campanulate, glandular-puberulent, distinctly scarious in the sinuses; teeth lance-subulate, cuspidate, longer than the tube; corolla flesh-colored, nearly 4 cm. long; tube slender, 1 mm. thick below and 2 mm. at the throat; lobes narrowly lanceolate, attenuate, nearly 1 cm. long; stamens unequally inserted far down the corolla-tube, included; style slender, about equaling the corolla-tube.

UTAH: Beaver City, 1877, *E. Palmer 329* (type, in herb. Columbia Univ.). This is also related to *G. aggregata*.

Gilia hutchinsifolia Rydb. sp. nov.

Gilia arenaria rubella Brand, Pflanzenreich 4^{250}: 103. 1907.

This differs from *G. arenaria* Benth. and *G. sinuata* Dougl. in the acute corolla-lobes and broad and again lobed divisions of the leaves. The description "*Caulis inferne (an morbo?) rufo-lanatus*," from which Dr. Brand adopted the varietal name, is wholly erroneous. The red coloring is simply grains of red sand adhering to the specimens. This is the reason of my not adopting the varietal name.

Gilia straminea Rydb. sp. nov.

Annual; stem 2–3 dm. high, glabrous, or rarely slightly glandular-puberulent above, straw-colored, simple below, with a few

almost erect branches above; basal leaves glabrous, firm, 1–2 cm. long, pinnately lobed, with lanceolate cuspidate-tipped lobes; stem-leaves sessile and partly clasping, lanceolate, sharply dentate with cuspidate teeth or entire; calyx-tube campanulate, 2 mm. long, somewhat scarious in the sinuses, sparingly glandular-puberulent; teeth subulate, 1 mm. long; corolla trumpet-shaped, 7–8 mm. long; tube nearly twice as long as the calyx; capsule exceeding the calyx; seeds 5 or 6 in each cell.

This is related to *G. sinuata*, but differs in the simple, straw-colored, essentially glabrous stem, the glabrous, pale green leaves, and the form and toothing of the stem-leaves.

UTAH: St. George, 1877, *E. Palmer 325*,* in part (type, in herb. Columbia Univ.); also *326*.

Dr. Brand reduced *Gilia Tweedyi* Rydb. to a variety of *G. minutiflora*, without having seen a specimen. I do not think that it is rational to do so, for in *G. Tweedyi* the pod is not 1-seeded, but bears 1–3, usually 2, seeds in each cell, i. e., it is 4-seeded. The plant is more closely related to *G. inconspicua*.

Dr. Brand made *Gilia Haydeni* A. Gray a variety of *G. subnuda* Torr., and gave *G. Crandallii* Rydb. as a synonym of this variety. Professor Nelson regarded *G. Crandallii* as the same as *G. subnuda* and gave *G. Haydeni* and *G. superba* Eastw. as varieties of the same. Both arrangements are incorrect. *G. superba* Eastw. is the typical *G. subnuda* Torr. characterized by the orange or scarlet corolla. In both *G. Haydeni* and *G. Crandallii* the corolla is rose-colored. They are quite distinct from *G. subnuda* and in my opinion distinct from each other.

Dr. Brand's treatment of *Leptodactylon pungens* (Torr.) Nutt. or *Gilia pungens* (Torr.) Benth. and its relatives is far from satisfactory. He divides it in two subspecies: subsp. A. *eu-pungens* and subsp. B. *Hallii* (*Gilia Hallii* Parish), which is a matter of taste, but he also divides the former in four varieties: a. *Hookeri* (Dougl.) Brand; b. *caespitosa* (Nutt.) Brand; c. *tenuiloba* (Parish) Brand; and d. *devestita* Brand.

The first variety is based on *Gilia Hookeri* Benth. To make this species a variety of *G. caespitosa* could be also passed over, as

* The same number in the herbarium of the New York Botanical Garden is entirely different, and belongs to *Gilia hutchinsifolia*. Maybe some mixing of the labels occurred.

a matter of taste, but Dr. Brand in his treatment usually meant by the variety *a* the typical form. If that is his intention here, he is wholly mistaken, for the type is not viscid. Torrey's type should be placed under his variety *b. caespitosa*, and is exactly like *Goodding 32* and *Parry 236* from Wyoming, which Dr. Brand also refers to that variety. In fact Dr. Brand seems not to know *Leptodactylum caespitosum* Nutt. (*Gilia pungens caespitosa* A. Gray), although he adopts this name for a variety which proves to be the original *G. pungens*. *Leptodactylon caespitosum* is amply distinct, not only by the characters given by Dr. Gray, but also by the 4-merous flowers and the stamens inserted in the tube. All the other species have 5-merous flowers. *Gilia Hookeri* is confined to the western slope and does not extend into Utah, Colorado, New Mexico, and Arizona, as stated by Dr. Brand. The following specimens are wrongly referred to it: *Elmer 502* is typical *G. pungens; Jones 1784* and *MacDougal 183* belong to *G. pungens squarrosa* A. Gray. The Matthews' specimens I have not seen, but I think they also are wrongly referred to it. Of the specimens cited under the variety *devestita*, all I have seen belong to typical *G. pungens*, some of them having slightly longer leaves than the type, but not all.

Leptodactylon brevifolium Rydb. sp. nov.

Suffruticose, branched perennial, 1–2 dm. high; stems puberulent and slightly glandular above; leaves 3–5 mm. long, glandular-puberulent or glabrate, 3–5-divided into subulate, acerose, ascending divisions; calyx about 8 mm. long, glandular-puberulent; teeth subulate-acerose, much shorter than the tube; corolla trumpet-shaped, about 15 mm. long; stamens inserted in the throat of the corolla.

This is related to *Leptodactylon pungens* (Torr.) Nutt. and *L. Hookeri* (Dougl.) Rydb. (*Phlox Hookeri* Dougl.; *Gilia Hookeri* Benth.) but has much shorter leaves. The habit and flower are more like the former, but the calyx and young foliage are more or less glandular, though not so copiously so as in the latter.

UTAH: Juniper Range, 1898, *Purpus 6306* (type, in U. S. Nat. Herb.; duplicate in herb. N. Y. Bot. Gard.); Cedar City, *M. E. Jones 5204a;* Montezuma Canyon, *Eastwood;* rocky hills on the San Juan, *Newberry.*

?COLORADO: Gunnison, Aug. 16, 1901, *Baker 830* (doubtful, without flower).

NEW MEXICO: Cedar Hill, San Juan County, *Standley 7998.*

WASHINGTON: Coulee City to Ephrata, June 1902, *Griffiths & Cotton 471.*

NEVADA: Panaca, *V. Bailey 1971.*

Dr. Brand excluded *Gilia caespitosa* A. Gray not only from the genus but also from the family. He makes the following remark: "Species foliis calcareo-glandulosis ab omnibus Polemoniaceis valde abhorret; fortasse Saxifragaceis attributa est."

The leaves are by no means "calcareo-glandulosis," but merely viscid-pubescent as described by Dr. Gray. In the type they are covered by grains of sand, that is all. It is without doubt a species of *Gilia* and probably, as Dr. Gray suggested, related to *G. subnuda*, but as the corolla was unknown the placing in the genus was uncertain. One thing is certain, it should not be placed next to *G. rigidula* as it is in the Synoptical Flora. The duplicate of the type in the National Herbarium bears a single withered and partly torn corolla; this is trumpet-shaped and about 1 cm. long; the real structure is not possible to make out, but the plant is probably related to *G. subnuda.*

Dr. Brand gives *Micranthes diffusa* as a synonym under *Gilia gracilis* subspecies *humulis* var. *micrantha*, while he cites *Heller 3098* (its type) under *G. gracilis* subsp. *eu-gracilis* var. *eritrichoides*, which shows carelessness in identifying the different forms described. In the Columbia University herbarium there is a duplicate of Douglas's collection, which shows that Brand's var. *eritrichoides* is the typical form of *Microsteris gracilis* (Dougl.) Greene.

Dr. Gray in his Synoptical Flora* segregated out *Gilia aristella* from material he had previously included in *Collomia linearis subulata.* The latter he regarded as the same as *Collomia tinctoria* Kellogg. Notwithstanding this judgment of Dr. Gray, which always will weigh considerably, Dr. Brand made *Collomia aristella* (A. Gray) Rydb. a synonym of *C. tinctoria* Kellogg, while he named *C. tinctoria subulata* (A. Gray) Brand from Gray's variety *C.*

* 2[1]: Suppl. 408. 1886.

linearis subulata. Dr. Brand did not give any reason for this change. Furthermore, he did not cite any specimens of his *C. tinctoria* from California and I have seen no specimens of *C. aristella* from that state. Of the variety *subulata*, on the contrary, there are several collections from California in our herbaria. There is nothing either in Kellogg's description or in his figure which would indicate that Dr. Gray had made a misinterpretation. Kellogg's figure is drawn from a young, simple, undeveloped plant, and the peculiar branching of the var. *subulata* in age does not show. Whether *C. tinctoria* and *C. aristella* should be united into one species is another question, but in such a case the variety *subulata* should have been made the species, viz., *C. tinctoria* Kellogg, and *C. aristella* a variety thereof; and this for the following reason: The variety *subulata* is certainly found in the type region of *Collomia tinctoria*, while *C. aristella* apparently is not. Seen from another standpoint, the local and more specialized *C. aristella* must be regarded as the derivative of the more common and less specialized *C. tinctoria* (i. e., the var. *subulata*).

Brand transferred *Gilia sinister* M. E. Jones to *Collomia* without having seen the plant. This was probably because Mr. Jones placed it in the *Collomia* section and compared it with *G. aristella*. But Jones also made the following statement: "This has the general appearance of *G. inconspicua*, but without the basal leaves." The relationship is also with *G. inconspicua*. Several of the species of that group have the calyx enlarged somewhat in fruit; this is true in *G. sinister*, but it is at last ruptured by the capsule and does not have the structure of the calyx in *Collomia*. It is in my opinion a true *Gilia*.

Dr. Brand included a number of forms, in my judgment several good species, under *Polemonium pulcherrimum* Hook. He divides it in three subspecies, *tricolor*, *delicatum*, and *parvifolium*. The first is separated by its tricolored flowers and equals *P. tricolor* Eastw. The other two subspecies he separated only by the length of the leaflets, a very poor character to use for separating subspecies.* He overlooked the fact that in all these forms included

* Under var. *Haydenii* Dr. Brand made the following remarks: "The forms from the southern Rocky Mountains, which could be counted to this, are better to be regarded as depauperate forms of subsp. *delicatum*."

in the subspecies *delicatum*, the stem is pubescent with long white spreading hairs and the leaflets are decidedly acute, while in the forms included in the subspecies *parvifolium*, the stem is merely puberulent and the leaflets usually obtuse.

The specimens cited under the subspecies *delicatum* belong to three or four different species. Those from Colorado and Utah belong to *P. scopulinum* Greene and *P. delicatum* Rydb., which perhaps may not be specifically distinct. Those from California belong to *P. californicum* Eastw. Those from Washington and perhaps those from Oregon to an undescribed species, characterized below.

The subspecies *parvifolium* was divided in var. α *Haydenii* and var. β *pilosum* (= *P. pilosum* Greenman). It is very hard to interpret Dr. Brand's arrangement. He gives under the subspecies *parvifolium* the following synonyms: *P. parvifolium* Nutt.; *P. coeruleum* J. Hook.; *P. mexicanum* Nutt.; *P. viscosum* A. Gray, not Nutt., but cited no specimens. His usage as well as that of most European botanists is to designate the typical form by var. α. Hence var. α *Haydenii* is the typical form of subsp. *parvifolium*, and still under this he has the following synonyms: *P. Haydeni* A. Nels., *P. montrosense* A. Nels., and *P. Tevisii* Eastw. *P. parvifolium* Nutt. is the same as *P. mexicanum* Nutt. and *P. viscosum* A. Gray, and is characterized by its small dense inflorescence and its obtuse calyx-lobes, or the latter even rounded at the apex; but it is not the same as *P. coeruleum* γ Hook., or *P. Haydeni* A. Nels., or *P. Tevisii* Eastw.

Polemonium coeruleum γ Hook. is the original *P. pulcherrimum* Hook., and this should have been made subsp. A var α, according to Brand's system. *P. Haydeni* resembles it closely in flowers, leaves and pubescence, but differs considerably in general habit and the inflorescence.

Polemonium columbianum Rydb. sp. nov.

Perennial, with a branched rootstock and caudex; stems several, 2–3 dm. high, viscid-pubescent with flattened hairs, and distinctly glandular in the inflorescence; leaves 5–15 cm. long, likewise sparingly viscid-pubescent, pinnate; leaflets 9–19, elliptic or lance-elliptic, acute, 1.5–3 cm. long; inflorescence corymbiform-paniculate; calyx about 6 mm. long, glandular-puberulent and

pubescent; lobes lanceolate, acute, fully equaling the tube; corolla 10–12 mm. long, open-campanulate, violet with yellowish base; lobes rounded-truncate at the apex; stamens two thirds to three fourths as long as style and slightly longer than the corolla.

This resembles *P. scopulinum* Greene in habit, but is a larger plant with much larger flowers. It grows in the mountains of Idaho and Washington at an altitude of 1,500–2,000 m.

IDAHO: Divide between St. Joseph and Clearwater Rivers, July 9, 1896, *Leiberg 1205* (type, in herb. N. Y. Bot. Gard.); Wiesner's Peak, July 8, 1892, *Sandberg, MacDougal & Heller 1049.*

WASHINGTON: Wenatchee Mountains, July, 1897, *Elmer 456;* Goat Mountain, Aug. 12, 1896, *Allen 262;* Clallam, July, 1900, *Elmer 2819;* Palace Camp, 1883, *Mrs. Bailey Willis.*

Polemonium intermedium (Brand) Rydb. sp. nov.

Polemonium occidentale intermedium Brand, Pflanzenreich 4^{250}: 33. 1907.

This I think is well worth specific rank. It is confined to the Columbia River region of Idaho, Washington, and British Columbia.

Dr. Brand regarded *Polemonium speciosum* Rydb. as a good species. Professor Nelson on the other hand makes it a variety of *P. mellitum* (A. Gray) A. Nels., which is evidently erroneous. If it should be made a variety of any of the verticillate species of *Polemonium,* it should have been of *P. viscosum* Nutt. or rather of *P. Grayanum* Rydb., which species Professor Nelson does not regard as distinct. *P. speciosum* has a short blue corolla and subcapitate inflorescence.

HYDROLEACEAE

Hydrophyllum Watsonii (A. Gray) Rydb. sp. nov.

Hydrophyllum occidentale Watsonii A. Gray, Proc. Am. Acad. 10: 314. 1875.

Miltitzia foliosa (Jones) Rydb.

Emmenanthe foliosa M. E. Jones, Zoe 4: 278. 1893.

The *Miltitzia* section of *Emmenanthe* of Gray's Synoptical Flora, I think is generically distinct from *Emmenanthe* proper,

and DeCandolle's genus *Miltitzia* should be restored. The latter genus is represented in the Rocky Mountain region by this and the two following species.

Miltitzia salina (A. Nels.) Rydb.

Emmenanthe salina A. Nels. Bull. Torrey Club **25**: 381. 1898.

Miltitzia scopulina (A. Nels.) Rydb.

Emmenanthe scopulina A. Nels. Bull. Torrey Club **25**: 380. 1898.

Phacelia orbicularis Rydb. sp. nov.

Biennial or annual; stems 1–2 dm. high, glandular-villous, often tinged with red, branched; leaves petioled; blades suborbicular in outline, crenately lobed, 1.5–2.5 cm. long, hirsute as well as glandular; racemes many-flowered; calyx-lobes oblong or oblanceolate, obtuse, 3 mm. long; corolla purplish, 6 mm. long, campanulate-funnelform; lobes crenulate; filaments about twice as long as the corolla; seeds faveolate, crenately lobed on the margins and the median ridge.

This is related to *P. integrifolia*, but the plant is smaller and the leaf-blades shorter and broader.

UTAH: Marvin Laccelite, 1894, *M. E. Jones 5663* (type, in U. S. Nat. Herb.).

Phacelia crenulata Torr., *P. bicolor* Torr., *P. affinis* A. Gray, *P. glechomaefolia* A. Gray, *P. hispida* A. Gray, *P. humilis* T. & G., *P. demissa* A. Gray, *P. Palmeri* Torr. (not *P. Palmeri* Vasey & Rose), *P. pinetorum* Jones, and *P. pusilla* Torr. have been collected in Utah; *P. glandulifera* Piper and *P. ramosissima* Dougl., in Idaho. I cannot distinguish *P. luteopurpurea* A. Nels. from *P. glandulifera* Piper. *Capnorea incana* Greene, *C. nana* (Lindl.) Raf., *C. nervosa* Greene, and *C. Watsoniana* Greene have been collected in Idaho; the first one also in Montana and the last one in Wyoming; *Emmenanthe penduliflora* Benth. and *Eriodictyon angustifolium* Nutt. in Utah.

BORAGINACEAE

Gruvelia setosa (A. Gray) Rydb.

Pectocarya setosa A. Gray, Proc. Am. Acad. **12**: 81. 1877.

I think that the genus *Gruvelia* A. DC. should be restored, being quite distinct from *Pectocarya*. The only other species is *G. pusilla* A. DC., the type of the genus.

Professor Nelson both in the original diagnosis* and in Coulter & Nelson's New Manual† described *Lappula erecta* as having the marginal prickles in a single row, but a duplicate of the type in the Columbia University herbarium and all specimens distributed as *Lappula erecta* by Professor Nelson himself in the herbarium of the New York Botanical Garden have a double row of marginal prickles, the prickles of the outer row being somewhat smaller than those of the inner.

Oreocarya pustulosa Rydb. sp. nov.

Perennial, branched at the base; stems 3–5 dm. high, glabrous or nearly so throughout, lower leaves linear-oblanceolate, the upper linear or linear-lanceolate, 3–10 cm. long, green, glabrous beneath, sparingly hairy above; the hairs short and at least in age with conspicuous pustulate bases; flowers paniculate; branches racemose, not secund; pedicels 1–2 mm. long; sepals triangular-lanceolate, acute; corolla white; tube not exceeding the calyx; limb 5–6 mm. broad; lobes orbicular; fruit depressed-globose; nutlets smooth, nearly white, mottled with light brown, more or less separated from each other on the margins, often not all maturing.

This is related to *Oreocarya multicaulis* (Torr.) Greene, *O. suffruticosa* (Torr.) Greene and the Mexican *O. Palmeri* Greene. It differs from the first two in the glabrous stem, green leaves, and light nutlets, and from *O. Palmeri* in broader leaves and different habit. It grows in canyons at an altitude of 1,700–2,000 m.

UTAH: Hammond Canyon, Elk Mountains, July 31, 1911, *Rydberg & Garrett 9320* (type, in herb. N. Y. Bot. Gard.); also same locality, Aug. 9, 1911, *9569;* Dry Wash, southwest of Abajo Mountains, August 10, *9590*.

Oreocarya Macounii Eastw. sp. nov.

Biennial or perennial with a slender tap-root; stem slender, 1–2 dm. high, sparingly hirsute; leaves narrowly linear or narrowly linear-oblanceolate, sparingly hirsute; inflorescence racemiform with short branches; corolla white, 5 mm. long, 4 mm. wide; nutlets ovate, obtuse, 2 mm. long, acutely margined, rounded on the back and coarsely muricate.

SASKATCHEWAN: Moose Mountain Creek, July 6, 1880, *John*

* Bull. Torrey Club **27**: 268. 1900.

† 412. 1909.

Macoun; also a specimen from Hooker's herbarium without date, probably collected by Richardson, at Carlton House. (Both in herb. Columbia University.)

Cryptanthe flexuosa A. Nelson is, I think, the same as *C. calycosa* (A. Gray) Rydb., and *C. muriculata montana* A. Nels. should be referred to *C. ambigua* (A. Gray) Greene, and *C. Hillmani* A. Nels. to *C. Watsoni* (A. Gray) Greene. *C. flaccida* (A. Gray) Greene has been collected in Idaho; *C. recurvata* Coville, in Utah and Colorado.

Mertensia coriacea A. Nels. is the same as *M. lanceolata* Pursh. Professor Nelson gives the range of *M. lanceolata* as Colorado and Wyoming. The type came from western Montana. *M. perplexa* is not the same as *M. coriacea*, as stated by Professor Nelson, but belongs to the *M. alpina* group with subsessile anthers.

Anchusa officinalis L. and *Asperugo procumbens* L. have been collected in Colorado; *Plagiobotrys arizonicus* (Gray) Greene in Utah; *P. tenellus* A. Gray in Idaho; *Cynoglossum officinale* L. in Wyoming and Montana; *Eremocarya muricata* Rydb. in Utah; *Lithospermum arvense* L. in Utah; *Mertensia brachycalyx* Piper in Idaho; *M. pulchella* Piper, *M. nutans* Howell, and *M. longiflora* Greene in Idaho and Montana; *Amsinckia hispidissima* Suksd., *A. retrorsa* Suksd. and *A. micrantha* Suksd. have been collected in Idaho.

Pectocarya miser A. Nels. I can not distinguish from *P. penicillata* (H. & A.) A. DC. *Eddya hispidissima* Torrey has been collected in Utah.

VERBENACEAE

Verbena remota Benth. was collected in southeastern Utah in 1911 by Professor Garrett and myself. *Verbena bipinnatifida* Nutt. is very rare in the region and *V. canadensis* (L.) Britton does not occur at all. The range given in Coulter & Nelson's New Manual is erroneous. The group is represented in the Rocky Mountains by *V. ambrosifolia* Rydb., *V. Gooddingii* Briq., and *V. ciliata* Benth.

LAMIACEAE

Lamium amplexicaule L. has been collected in Colorado; *Micromeria Douglasii* Benth. and *Trichostoma oblongum* Benth., in Idaho.

Monarda Nuttallii A. Nels. or *M. citriodora* of Coulter's Manual is *Monarda pectinata* Nutt.

Salvia Columbariae Benth. has been collected in Utah.

SCROPHULARIACEAE

Miss Eastwood has called to my attention that *Pentstemon acuminatus*, *P. humilis* Nutt., and *P. glaucus* Graham have been misinterpreted. *P. acuminatus* is a species confined to the Columbia Valley, has a more ample corolla, perfectly glabrous within; the tongue of the sterile filament is strongly curved and only short-bearded at the apex. Whether the so-called *P. acuminatus* of the Rocky Mountain region is a distinct species or should be included in *P. nitidus* Dougl. is hard to tell. A duplicate of the type of the latter is in the Columbia University herbarium, but this, as well as several other specimens, does not have the broad, abruptly acuminate bracts, characteristic of the so-called *P. acuminatus*, but there is no other distinction and intermediate forms are not lacking.

The original *P. humilis* Nutt. is, according to Miss Eastwood, the same as *P. collinus* A. Nels., which therefore passes into synonymy. Dr. Gray in describing *P. humilis** makes Nuttall's plant the type, but evidently had another plant mostly in his mind, viz. *Parry 257* and from this we have received our usual idea of *P. humilis*. This probably should be known as *P. albertinus* Greene,† which apparently is the same. Professor Nelson gives *P. pseudohumilis* Rydb. as a synonym, but this is the same as his own *P. Owenii*.

Pentstemon glaucus Graham does not belong to the group where Dr. Gray placed it and has nothing to do with the Rocky Mountain plant *P. stenosepalus* (Gray) Howell (*P. glaucus stenosepalus* A. Gray), but belongs to the *P. confertus* group. It is evidently the same as *P. pinetorum* Piper or closely related to it.

Pentstemon Macbridei A. Nels.‡ and *P. perpulcher* A. Nels. are apparently *P. Cusickii* A. Gray and *P. unilateralis* Rydb., respectively. A duplicate of the type of *P. Cusickii* is in the herbarium

* Proc. Am. Acad. **6**: 69. 1862.

† Leaflets **1**: 167. 1906.

‡ Bot. Gaz. **52**: 272, 273. 1911.

of Columbia University. The type of *P. unilateralis* is in that of the New York Botanical Garden. Recently botanists have overlooked the fact that in *P. speciosus* the anthers are perfectly glabrous and not short-bearded as in *P. glaber*. Dr. Gray overlooked the fact that *Pentstemon humilis* Nuttall is a member of the *P. erianthera* group and closely related to *P. miser* A. Gray, and placed it near *P. caespitosus* Nutt. Gray's two varieties of *P. humilis*, however, have nothing to do with it, and belong to the *P. caespitosus* group. The variety *Thompsoniae* has been already raised to specific rank and var. *incanus* is probably a form of it.

Pentstemon Leonardi Rydb. sp. nov.

Low perennial, suffruticose at the base; stems 1–2 dm. high, leafy, glabrous or minutely puberulent; leaves oblanceolate, 2–4 cm. long, short-petioled, glabrous; inflorescence short and often somewhat secund; calyx glabrous, about 6 mm. long; lobes lanceolate, acuminate, not scarious-margined; corolla 12–15 mm. long, rose-purple, only slightly ampliate, glabrous within; anthers horseshoe-shaped, saccate, opening only on the proximal one third, hispidulous on the margins of the pores, otherwise glabrous.

This belongs to the *P. azureus* group and has been confused with *P. Kingii*, but the leaves are broader and glabrous, the corolla less ampliate, the sepals not glandular and more acuminate. It differs from *P. platyphyllus* in the low habit and the smaller oblanceolate leaves.

UTAH: Diehl's Grove, Wahsatch Mountains, Aug. 1, 1884, *Leonard* (type, in herb. N. Y. Bot. Gard.); Deer Creek, *M. E. Jones;* Wahsatch Mountains, July, 1888, *J. H. Paul;* Central Utah 1875, *Parry 72*.

IDAHO: Franklin Basin, Bear River Range, July 24, 1910, *C. P. Smith 2278*.

Mimulus Eastwoodiae Rydb. sp. nov.

Mimulus cardinalis Eastw. Bull. Calif. Acad. II. **6**: 312. 1896. Not *M. cardinalis* Dougl. 1842.

Perennial, with rootstock and stolons; stem 1–2 dm. long, viscid-villous; leaves sessile, coarsely dentate, viscid-villous, 3–5-ribbed, sessile, 2–5 cm. long, the lower cuneate and truncate, the upper obovate or broadly oblanceolate and acute; stolons 1–3 cm. long, rooting at the end and nodes; their leaves less than 1 cm.

long; flowers mostly solitary; pedicels 1–4 cm. long; calyx narrowly funnelform, strongly 5-angled; lobes nearly equal, lanceolate, about half as long as the tube; corolla crimson, 3–4 cm. long, scarcely ventricose; anthers sparingly bearded.

This is related to *Mimulus cardinalis*, to which Miss Eastwood referred it with some hesitation. She also pointed out the low habit and more sharply toothed leaves, but did not notice the most striking feature of the plant, viz., its stolons, which are sent out after blooming. By means of these the plant, growing as it does in crevices of perpendicular or overhanging cliffs, can propagate itself in every direction. Wherever a stolon touches the rock and the root can get a foothold, a new plant is formed, even under the overhanging rocks. In the latter case the plantlet formed will be growing, the following year, with the roots up and the flowers down.

UTAH: In cervices of perpendicular or overhanging rocks, along San Juan River, near Bluffs, August 25–29, 1911, *Rydberg 9883* (type); also the same locality, *Miss Eastwood.*

Veronica Buxbaumii Tenore has been collected in Utah and *V. arvensis* L. in Idaho. *Veronica peregrina* L. is not found in the Rocky Mountain region. All specimens so named from there belong to *V. xalapensis* H. B. K. *Antirrhinum Cooperi* A. Gray and *A. Kingii* S. Wats. have both been collected in Utah; *Moniera rotundifolia* Michx. in Montana; *Gratiola ebracteata* Benth. in Montana and Idaho.

Triphysaria hispida (Benth.) Rydb.

Orthocarpus hispidus Benth. Scroph. Ind. 13. 1835.

In the genus *Cordylanthus* [*Adenostegia*] Coulter & Nelson* have transposed the color characters of the corolla of *C. Wrightii* and *C. ramosa*. *Adenostegia capitata* (Nutt.) Greene has been collected in Idaho and *A. canescens* is common around Great Salt Lake. *Cordylanthus bicolor* A. Nels. is evidently the same as *Adenostegia ciliosa* Rydb.

Castilleja subcinerea Rydb. sp. nov.

Perennial with a branched short caudex; stems 3–5 dm. high, canescent-strigose, stout; leaves more or less canescent, strongly

* See Manual 462. 1909.

3-ribbed, 5–7 cm. long, the lowest entire, linear, the upper 3-cleft; bracts broadly cuneate in outline, 5–7-cleft, canescent, the lower grayish green, the upper tinged with yellow and often brown-tipped; calyx canescent, 2.5 cm. long, equally cleft above and below, each lobe 2-cleft; corolla greenish yellow; upper lip 9 mm. long; the lower about 3.5 mm. long, slightly saccate.

It may be related to the *C. hispida* group, but the plant is grayish strigose, and the bracts yellow-tinged.

IDAHO: Beaver Canyon, June 28, 1895, *C. L. Shear 3041* (type, in herb. N. Y. Bot. Gard.); also *3038;* mountains near Indian Creek, July 21, 1897, *Rydberg & Bessey 4969* (at least in part).

Euphrasia mollis (Ledeb.) Wettst. has been collected in Montana; *Pedicularis lanata* Willd. and *P. flammea* L. in the Canadian Rockies; *P. Oederi* Vahl in Montana and *P. centranthera* A. Gray in Utah and Colorado.

OROBANCHACEAE

Thalesia purpurea Heller, *T. minuta* (Suskd.) Rydb. and *T. Sedi* (Suksd.) Rydb. have been collected in Montana and northern Idaho, and *Myzorrhiza pinetorum* (Geyer) Rydb. in Idaho.

LOBELIACEAE

Howellia aquatilis A. Gray and *Heterocodon rariflorum* Nutt. have been collected in Idaho and *Nemacladus ramosissimus* Nutt. in south Utah.

NEW YORK BOTANICAL GARDEN.

Observations on the geographical composition of the Sugar Grove flora *

ROBERT F. GRIGGS

The Sugar Grove area is one of those places which are sometimes found where the botanical interest of a large region may be said to come to a focus. Not only do the plant associations, both upland and lowland, characteristic of eastern Ohio reach their climax here as nowhere else but about one plant in eight of the native flora, nearly one hundred and twenty in all, reaches here the edge of its range. These include species stretching away in every direction, north, south, east, and west. A study of the ranges of these plants shows that the area is the key to an understanding of the plant geography of Ohio.

This region is a narrow strip of very rough and rugged sandstone country extending from near the town of Sugar Grove, Fairfield Co., Ohio, southward for about twenty miles to the canyon of Queer Creek east of South Bloomingville, Hocking Co. Its position is roughly indicated by an ellipse in FIGURES 1, 2. It is located at the end of the long lobe of the Alleghenian floral area which Merriam's† map shows stretching into northeastern Ohio, a location which of itself marks it as an interesting region. It has been long known as an exceedingly rich collecting ground and contains an unusual number of rare plants not found elsewhere in Ohio.

In most of the published work on plant geography the area considered is divided into zones which are plotted on the map. Although the boundary lines of the zones are always difficult to settle, this method reaches results satisfactory to the geographer, who is primarily interested in subdividing the area of the earth. Not so however to the botanist, who is interested in plants rather

* Contribution from the Botanical Laboratory of the Ohio State University No. 75.

† Merriam, C. Hart. Life zones and crop zones. U. S. Dept. Agr. Biol. Survey Bull. 10. 1898.

than in areas. For by this method no locality can be possibly assigned to more than two zones whereas the flora of most regions is composed of numerous groups of plants of diverse affinities. The adequate representation of these requires not one but many maps each portraying a typical range. In the present paper an attempt is made to treat the Sugar Grove flora in this fashion.*

It is however very difficult to secure the data necessary for a consideration of plant ranges and the results are necessarily crude in consequence. There has been as yet almost no exact research into the ranges of North American plants. Only in the case of a few specially interesting species has any great effort been made to ascertain the facts of distribution. The ranges assigned to our plants in the manuals, even the most careful of them, are to a considerable extent the result of tradition and guesswork and are frequently far from accurate, while in works like Hough's Trees, which is almost the only general work that has attempted to map ranges, the maps given are so inaccurate as to be almost useless for detailed work. The importance of reliable data of this sort may be brought out by an example. The chestnut, *Castanea dentata*, whose distribution is much talked of just now in estimates of the probable damage to be expected from the chestnut blight, *Endothia parasitica*, is usually given† as occurring over all of Ohio except the extreme northwest corner and much of Indiana. But in reality‡ it is confined to the vicinity of the Lake Shore around the western end of Lake Erie, is entirely absent from western Ohio but occupies eastern Ohio and stretches through the southern part of the state into southern Indiana—thus lessening the area susceptible to damage by the blight by something more than 10,000 square miles.

The labor involved in determining accurately the range of a single plant is not inconsiderable. There is not a single herbarium

* For his conception of this point of view and for the ideas which are stimulated and exchanged during many friendly discussions as well as for more specific suggestions the writer is very greatly indebted to Professor M. L. Fernald of the Gray Herbarium. For a discussion of the flora of Newfoundland from this point of view see his "Botanical Expedition to Newfoundland and Southern Labrador," Rhodora 13: 135–162. 1911.

† See map opp. p. 28 in Rep. Pennsylvania Chestnut Blight Conference. Harrisburg, 1912.

‡ See map opp. p. 180, l. c.

in the country large enough in itself to supply the data for a rough approximation of the range of even our better known species. He who would accumulate information of this sort must visit half a dozen herbaria to get even a general view of the ranges of our common plants. Recourse must also be had to numerous local floras, where such are available, and the correctness of their identifications must be taken on faith. Moreover even our best known species have not been collected enough as yet to supply

FIG. 1. Distribution of *Lycopodium* in Ohio.

1. *L. clavatum.*
2. *L. complanatum.*
3. *L. inundatum.*
4. *L. lucidulum.*
5. *L. lucidulum porophilum.*
6. *L. obscurum.*

satisfactory data as to their distribution and there are still hundreds of species the very characters of which are not yet understood.

The difficulty of getting adequate data for such work at present may be illustrated from Fernald's careful paper cited above, in which *Thuja occidentalis* is mapped as barely reaching Ohio whereas it occurs over the central and south central part of the state as far as Delaware, Champaign, and Highland counties; *Aster macrophyllus* likewise is found over northeastern Ohio to Hocking county, although it is given as barely touching the northeastern corner of the state. These illustrations are not cited in any spirit of criticism but at once to call attention to the importance of *local* work of this sort, and to forestall criticism of the maps given herewith, which are probably equally faulty.

It has seemed wise not to indicate the edges of the ranges but rather to show known stations. Those stations from which the writer has seen a specimen are marked with a "bullseye" while those which were compiled from the literature are marked by a circle without the central dot. The maps are thus capable of indefinite extension as more stations are found or more specimens seen.

Fortunately for the purposes of this paper we have in the state of Ohio, thanks to the energy and enthusiasm of the late Dr. W. A. Kellerman, a very representative state herbarium which is indexed by counties after the fashion of the state maps herewith reproduced. Although by no means complete as yet these maps enable one to learn relatively accurately the distribution of the flora over the state simply by glancing at the index. Curiously enough the distribution in Ohio often gives almost no clue as to the range of a species. Thus *Populus heterophylla* is confined to the northern half of Ohio but in Indiana it is confined to the southern portion! On further examination its range is found to be the Atlantic coastal plain from southern Connecticut around the Gulf coast and up the Mississippi and Wabash River systems to the basin of Lake Erie.

One's general expectation concerning plant distribution is, that being controlled by climate, the termini of the ranges follow the parallels of latitude in a general way, crossing the state from

east to west. In Ohio, however, the reverse is the case; most of the termini run in north and south lines. As one examines the card catalog he soon finds several types of distribution that are of frequent occurrence. By far the most common of these covers

FIG. 2. Range of *Oxydendrum arboreum* in Ohio.

the northeastern quarter of the state extending south to the present area along the lines of Merriam's map. This may be illustrated by the distribution of *Lycopodium* in Ohio (FIG. 1). Almost as conspicuous is a second group which extends north from the Ohio River and occupies a triangular area with its apex at Sugar Grove. The sorrel-tree, *Oxydendrum arboreum*, is a typical example (FIG. 2).

Each of these when the whole range of the plants concerned is taken into consideration is found to be a composite of several types of distribution. These together with others belonging to types not so conspicuously homogeneous within the state may be classified as follows:

A. ALLEGHENIAN PLANTS ON THE SOUTHWESTERN EDGES OF THEIR RANGES.

Type range, BETULA LUTEA (FIG. 3).

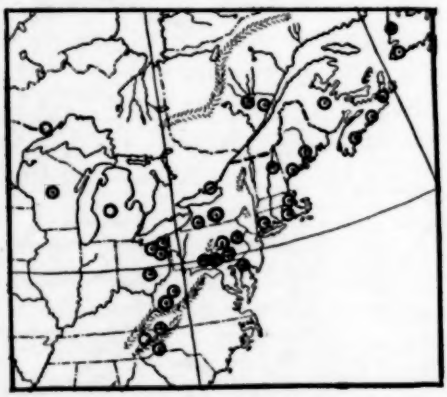

FIG. 3. Range of *Betula lutea*.

This list includes beside the Alleghenian plants which go no further west than the Lake Superior region, some Canadian plants which stretch across the continent. Though these are more northerly and fewer of them reach Ohio, the ranges of those that we do have are so similar to the Allegheny type that they are inseparable. *Capnoides sempervirens* (FIG. 4) and *Cornus canadensis*, which terminates about twenty miles north of our area, are typical examples. Although this is a very homogeneous group of plants, conforming very closely to the typical range, many of them are also found in outlying stations far removed from the main range, as for example *Blephariglottis lacera* and *Tsuga canadensis*. There is also a tendency which may become more evident when more collections are available, for some of them to extend into southwestern Ohio and southern Indiana, e. g. the chestnut. This list includes 39 species as follows:

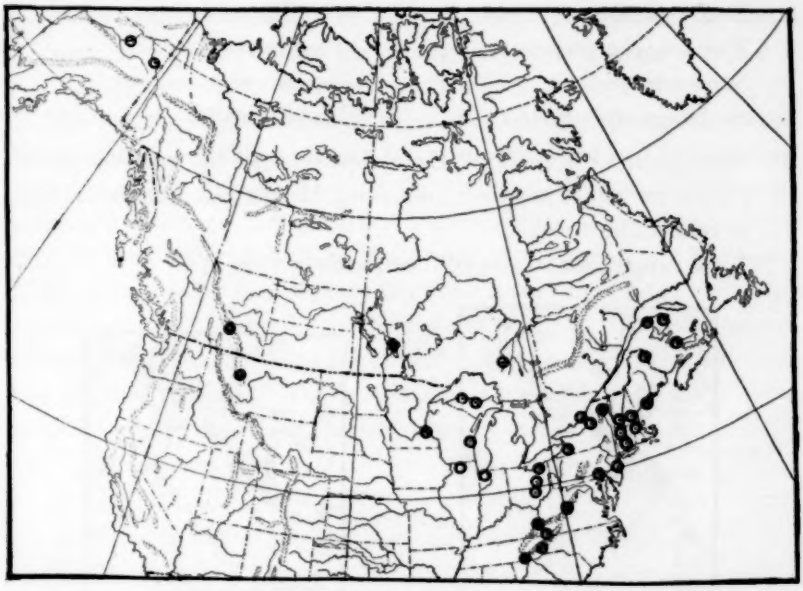

FIG. 4. Range of *Capnoides sempervirens*.

Achroanthes unifolia
Aronia nigra
Aster macrophyllus
Betula lutea
Blephariglottis lacera
Capnoides sempervirens
Chimaphila maculata
Chrysosplenium americanum
Circaea alpina
Cypripedium acaule
Cypripedium reginae
Epigaea repens
*Fraxinus nigra**
Gaultheria procumbens
Gentiana crinita
Isotria verticillata
Juncoides s altuensis
Lycopodium clavatum
Lycopodium complanatum
Lycopodium lucidulum
Lycopodium lucidulum porophilum
Lycopodium obscurum
Lysias orbiculata
Lysimachia quadrifolia
Melampyrum lineare
Panicularia elongata
Panicularia pallida
Parnassia caroliniana
Polygonum arifolium†
Pyrola elliptica
Pyrola rotundifolia

* The Ohio and Indiana (fide Coulter) distribution would indicate that this belongs in group F, but I follow Hough's map and place it here. It is unknown south of Columbus.

† Too widely extended in Indiana and Georgia to be typical.

Rubus odoratus
Rynchospora glomerata
Sambucus pubens
Saxifraga virginiensis
Trollius laxus
Tsuga canadensis
Unifolium canadense
Viola rostrata.

B. APPALACHIAN AND NEW ENGLAND SPECIES ON THE WESTERN EDGES OF THEIR RANGES (reaching Maine but not extending west of Lake Erie).
Type range, SERICOCARPUS ASTEROIDES (FIG. 5).

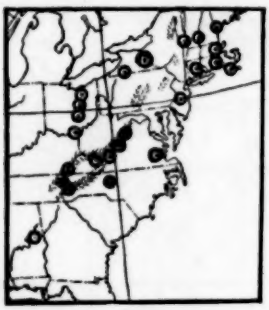

FIG. 5. Range of *Sericocarpus asteroides.*

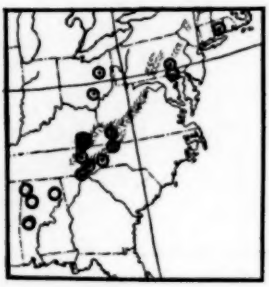

FIG. 6. Range of *Asplenium montanum.*

The lines separating this group of plants from the preceding and following categories are somewhat arbitrary. There are many plants of evident boreal affinities which are now confined to the Appalachians. Their ranges form a continuous series between the typical Alleghenian, extending from Newfoundland to Lake Superior, down to those like *Abies Fraseri* and *Tsuga caroliniana* which are confined to a small area in the highest part of the southern mountains. Those which reach Ohio, however, seem to fall rather naturally into the two categories here listed. Those of the first group number 14 and include:

Aster divaricatus
Carex costellata
Castanea dentata
Dasystoma laevigata
Eatonia nitida
Hieracium paniculatum
Hieracium venosum
Kalmia latifolia
Panicularia acutiflora
Pinus rigida
Quercus Prinus
Rhododendron maximum
Sericocarpus asteroides
Viola rotundifolia.

C. APPALACHIAN PLANTS (from southern New York or Connecticut to Ohio and south through the mountains).

Type range, ASPLENIUM MONTANUM (FIG. 6).

These ranges are in some cases difficult to distinguish from those of the Carolinian plants because their northern boundaries nearly coincide and because of the tendency to spread through southern Ohio into Indiana toward the Ozarks. In such cases the general affinities of the plant have been the criterion for decision. Thus *Aruncus Aruncus* is placed here because the same or a closely related species is found on the Pacific coast to Alaska thereby clearly indicating its boreal affinities although its distribution in the eastern United States is apparently clearly Carolinian. We have 12 plants belonging to this category as follows:

Aruncus Aruncus
Asplenium montanum
Asplenium pinnatifidum
Azalea lutea
Cardamine rotundifolia
Oxydendrum arboreum
Phlox stolonifera
Phacelia dubia
Pinus virginiana
Silene rotundifolia
Stachys cordata
Viola hirsutula.

D. CAROLINIAN PLANTS ON THE NORTHERN EDGES OF THEIR RANGES.

Type range, PASSIFLORA LUTEA (FIG. 7).

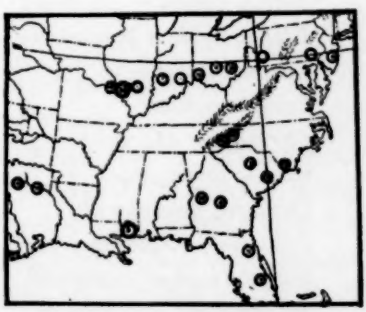

FIG. 7. Range of *Passiflora lutea.*

These are typically plants of southern or even subtropical affinity whose northern limits are largely determined by latitude. As might be expected, there is no such uniformity in the northern ranges of these plants as in those of the first group; *Ilex opaca, Quercus marylandica,* and *Liquidamber Styraciflua,* though members of this group, just reach the southern extremity of Ohio and do not come within 75 miles of Sugar Grove. The typical members of this group extend straight across the country at about the latitude of Philadelphia, but there is a strong tendency in many Carolinian plants like *Andropogon virginicus* (FIG. 8) to extend up the coastal

plain through New Jersey to Long Island or even to Massachusetts. These are starred (*) on the list. The coastwise distribution † of such plants finds its most striking exemplification in the occurrence

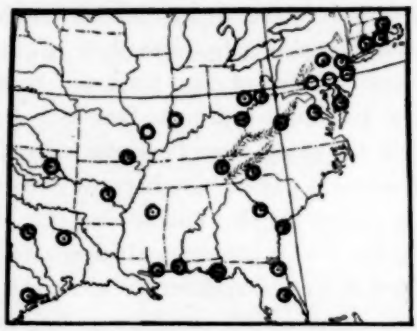

FIG. 8. Range of *Andropogon virginicus*.

of such a plant as *Schizaea pusilla* in Newfoundland.‡ The Carolinian plants which terminate at Sugar Grove number 32 and include:

*Andropogon virginicus
Aralia spinosa
*Aristida dichotoma
*Asclepias variegata
*Ascyrum multicaule
*Betula nigra§
Blephariglottis paramoena
Carduus virginicus
*Cassia nictitans
Chrysopsis Mariana
Cunila origanoides
Dentaria heterophylla
Diospyros virginiana
Eupatorium aromaticum
Eupatorium coelestinum
*Eupatorium rotundifolium
Hydrangea arborescens
Iris cristata
Koellia incana§
*Lechea racemulosa
Lobelia leptostachys§
Lobelia puberula
Napaea dioica§
Panicum polyanthes
Panicum stipitatum§
Passiflora lutea
Porteranthus stipulatus§
Quercus minor
*Solidago erecta
Stylosanthes biflora
Trichostema dichotomum§
Trifolium reflexum§

* Extending up the coastal plain into Long Island or New England.

† This interesting phenomenon has been described and its bearing discussed by Hollick, Plant Distribution as a Factor in the Interpretation of Geological Phenomena with especial reference to Long Island and vicinity. Trans. N. Y. Acad. Sci. 12: 189–202. 1893.

‡ See Fernald, l. c.

§ Not typical Carolinian plants. Of those marked thus, *Koellia incana*, *Panicum*

E. MISSISSIPPIAN PLANTS ON THE EASTERN EDGES OF THEIR RANGES. Type range, ISOPYRUM BITERNATUM (FIG. 9).

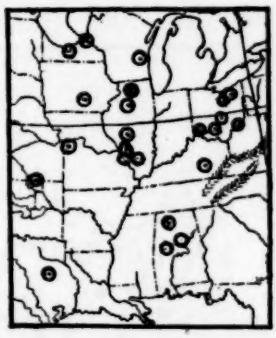

FIG. 9. Range of *Isopyrum biternatum*.

These are mostly plants characteristic of the great forest which once covered the Mississippi Valley and number 15 including:

*Aesculus octandra**
Aßzelia macrophylla
Asclepias Sullivantii
Bidens aristosa
*Brauneria purpurea**
*Dodecatheon Meadia**
Fraxinus quadrangulata
Hypericum Drummondii
Isopyrum biternatum
Psoralea Onobrychis
*Quamasia hyacinthina**
*Smilax ecirrhata**
Sullivantia Sullivantii
*Valeriana pauciflora**
Veratrum Woodii

F. PLANTS ON THE SOUTHERN EDGES OF THEIR RANGES. Type range, SCUTELLARIA GALERICULATA (FIG. 10).

This appears to be a miscellaneous aggregation without much similarity in range except that they are northern but not mountain plants. Probably further study and comparison would discover common characteristics as conspicuous as in other groups. Some of them like *Anemone canadensis* are bounded by the Basin

stipitatum, and *Trichostema dichotomum* have boundaries running from northeast to southwest instead of east and west while *Napaea dioica* reverses the case and is reported northwestward as far as Minnesota. *Porteranthus stipulatus* and *Trifolium reflexum* are transitional between this and the next group in that they do not cross the mountains but stop in western New York. *Lobelia leptostachys* also is not known much beyond the mountains and is likewise transitional to the next group.

* Also known locally further east but the main body of the range stops in Central Ohio.

of the Great Lakes. Others like *Salix amygdaloides* have a wide distribution westward but taper eastward in a triangular area with its vertex in western New York, thus conforming to Harsh-

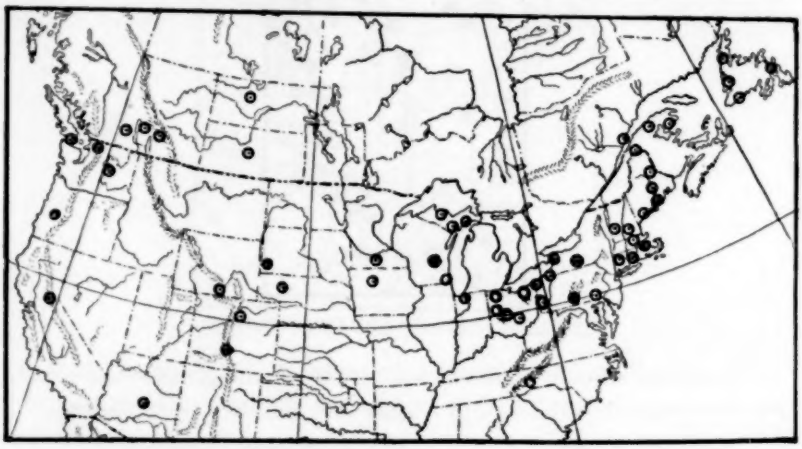

FIG. 10. Range of *Scutellaria galericulata*.

berger's* map of the Ohio-Tennessee area. 9 plants have been classed here as follows:

Anemone canadensis
Cornus stolonifera
Dasyphora fruticosa
Pedicularis lanceolata
Populus tremuloides
Salix amygdaloides
Saxifraga pennsylvanica
Scutellaria galericulata
Solidago juncea.

In addition to those given above there is one anomalous case which fits into no natural geographical range which I can discover. *Viburnum dentatum* comes down to our area from the northeast and meets *Viburnum molle* which comes up from the southwest. The characters which separate these species moreover do not hold in this region. It is evident therefore either that we do not understand these species and have only one of them even though there is a distinct variation from one part of the state to the other, or that they are not good species.

The presence at one place of so many species on the edges of

* Harshberger, J. W. Phytogeographic Survey of North America. Veg. der Erde 13: facing 790. 1911.

their ranges affords a favorable opportunity to study also their behavior. Are they rare or abundant? Does their reproductive apparatus function normally? Do those plants on their northern edges behave differently from those on their southern? The eastern from the western? Is it possible to assign any reasons for the location of their termini here rather than fifty or a hundred miles beyond? These questions will be considered in a following paper.

OHIO STATE UNIVERSITY,
COLUMBUS, OHIO.

The culture of cereal rusts in the greenhouse

F. D. Fromme

The desirability of maintaining cultures of parasitic fungi on the living host in the greenhouse for purposes of study and physiological experimentation is obvious, particularly so with those obligate forms that cannot be cultivated on artificial media. Methods of culture of the powdery mildews of the grasses and other members of the Erysiphaceae, and of a species of *Cystopus*, etc., Peronosporaceae, have been placed on an exact basis by the work of Reed (**28**, **29**) and Melhus (**23**). No exact data of this nature, however, are available for the rusts. Although a vast number of infection experiments on this group have been made in recent years, these have dealt only incidentally with conditions governing spore germination, infection, and spore formation, and in many cases our knowledge on these points is based on field experiments conducted under conditions not subject to rigid control. There are a great many scattered details in the literature as to conditions affecting the development of the rusts. I shall summarize only those that bear more especially on the problems of growing rusts in the greenhouse.

Smith (**33**) found that dew is of more importance in determining the prevalence of asparagus rust than rainfall. When little dew is formed infection cannot occur and sporulation may be checked, or altered, with a substitution of the teleuto for the uredo stage. This may occur in midsummer on the vigorously growing host as the result of excessive atmospheric dryness. He states, moreover, that abundance of soil moisture, instead of favoring rust development, acts as a check by giving the host greater vitality. This is in agreement with earlier observations by Stone and Smith (**34**, **35**). They found asparagus beds on light, dry soil heavily rusted while those on heavy, moist soil were comparatively free from rust. Sirrine's (**32**) observations also support the conclusion that dew is the most important agent in the spread of asparagus rust.

Morgenthaler (**25**) finds that mechanical injury of the leaves of the host favors teleuto as compared with uredo formation in the case of *Uromyces Veratri*. Tischler (**36**) found that shoots of *Euphorbia Cyparissias* infected with *Uromyces Pisi* became free from the rust mycelium when grown in a warm (25–27° C.) greenhouse.

Many factors doubtless influence the germination of rust spores. They frequently germinate in a few hours after being placed in water, as noted by de Bary. Often, however, though collected fresh, they fail to germinate for no apparent reason. This "capricious" germination has been noted by a large number of careful observers, and Eriksson, because of this uncertainty, does not consider the aecidiospores of the rusts of the cereals important factors in their dissemination. Schaffnit (**31**) explains this "capricious" germination on the ground that unless the spores are mature internally before detachment from their stalks they are incapable of germination. Complete maturity is attained only at a sufficiently high temperature (20°–25°) in an atmosphere calm enough to prevent their premature detachment. These conditions are not always realized in nature, hence the lack of uniformity in the results of germination tests.

Freeman (**13**) and Klebahn (**19**) both have found that spores which germinate poorly in water may produce an abundant infection on the host, and therefore argue that germination tests are not conclusive unless conducted on the host. Klebahn states that aecidiospores of *Peridermium Strobi* germinated slightly or not at all in water, very vigorously on the *Ribes* host and less vigorously, but abundantly, on a decoction of *Ribes*. Sappin-Trouffy (**30**) likewise noted a marked difference in the germination of aecidiospores of *Coleosporium Senecionis* in water and in a decoction of *Senecio vulgaris*. Schaffnit (**31**) on the other hand, obtained no increase in host decoctions over the germination in water nor any effect attributable to a mechanical excitation by the substratum. Marshall Ward (**37**), was unable to find any effect of raw or cooked extracts of various bromes on the germination of the uredospores of *Puccinia dispersa*.

The effect of various chemicals on rust spore germination has been investigated by Wüthrich (**40**) and Carleton (**6**). Wüthrich

(see TABLE I) has determined the inhibiting action of different concentrations of various acids and salts on the germination of aecidio- and uredospores of *P. graminis*. Carleton finds that compounds containing Hg, Cu, Fe, Pb, Cr, and strong acids inhibit the germination of uredospores of *Puccinia rubigo-vera*, *P. graminis* and *P. coronata* and that those which contain O, Na, K, Mg, S, C, and NH_3 in large proportions are favorable to germination.

The effect of temperature on spore germination has also received attention. Eriksson (9) found that aecidiospores of *Aecidium Berberidis*, *A. Rhamni*, and *Peridermium Strobi* and uredospores of *Puccinia glumarum*, *P. graminis* and *P. coronata* often germinated more readily at a few degrees below zero C. and on melting ice than at higher temperatures. Uredospores of *P. dispersa* according to Marshall Ward (37) germinate after freezing in ice for ten minutes. He attributes any increase in vigor obtained in this way to the drying action of the freezing and not to the low temperature. They germinated also at 27° but failed to do so at 30° and were killed at 65° to 70°. The optimum is near 20°. They germinate readily, if the spores are properly ripened and fresh and the temperature does not rise above 25°, in light, darkness, or red light, but less readily in blue light. Gibson (14) reports tests with uredospores of *Puccinia Chrysanthemi* as follows: Fifty per cent germination at 6°–6.5°, free germination between 7° and 21°, all at 21°–25°, one eighth at 24°–25°, and none at 30°. If kept dry at 35° for eighteen hours and then removed to 17° they germinate freely. Johnson (18) has determined the minimum, optimum, and maximum temperatures for germination of uredospores of the cereal rusts. These are: for *Puccinia graminis* on wheat, oats, and barley, 2° to 31°; for *P. rubigo-vera* on rye, 2°–30°; and for *P. coronata* on oats, 7°–8° to 30°. The optimum was determined by the general vigor of the germination tube and for all forms studied lies between 12° and 17°. This is somewhat lower than for *P. dispersa* as determined by Marshall Ward. Johnson suggests that these low cardinal temperatures may explain the difficulty of obtaining infections in very warm greenhouses and on hot summer days and may account for the observation that rust epidemics are favored by subnormal temperatures at critical infection periods.

The length of time during which uredospores of *P. graminis* retain their vitality was found by de Bary (3) to vary between one and two months, while the aecidiospores of the same form lost their color and capacity for germination in one month. Marshall Ward (38) obtained germination with uredospores of *P. dispersa* after having kept them in a dry state for 61 days. Miss Gibson (14) reports a germination of 25 per cent. with uredospores of *P. Chrysanthemi* after storage of 71 days but none a week later. One aecidiospore of a sowing of *Phragmidium Rosae-alpinae* germinated after storage of 82 days. Barclay (2) found uredospores of some forms capable of germination during periods of from two to eight months (see TABLE 1) in the Himalayas. Bolley (5) obtained a 5 per cent germination with uredospores of *P. graminis* after exposure to air and sunlight during the month of August.

Many observers have shown that various rusts are able to winter over in the uredo stage in some regions, but these data do not involve the determination of the actual time during which the spores are viable.

Gibson (14) has shown that a large number of uredospores will germinate on the leaves of the wrong host and that their germ tubes will enter the stomata without, however, producing an infection. In these cases the end of the germ tube dries up in the substomatal chamber without further development. Because inoculation does not always result in infection, Marshall Ward (37) would distinguish sharply between these terms which are often used interchangeably. The passage of the germ tube into the host should be spoken of as inoculation and the subsequent development in the tissue of the host as infection. Pole Evans (11) has investigated the entrance of the germ tubes of uredospores of *P. graminis*, *P. glumarum*, *P. simplex*, and *P. coronifera* into the stomata of their respective hosts and the establishment of the mycelium in the tissue of the host. The uredospores germinate within twenty-four hours and the infection is well established by the third day. When the germ tube reaches a stoma it forms a swelling or appressorium directly over it. A branch from the appressorium next enters the stomatal slit and forms a large vesicle in the substomatal chamber into which the contents of the appres-

sorium and germ tube are poured. One or more infecting hyphae are now sent off from the substomatal vesicle and these immediately establish connections with the surrounding host cells by means of haustoria. The early stages of development and the position and shape of the substomatal vesicle, and the number of infecting hyphae arising from it, are morphological distinctions between the different species.

In the rusts the period between inoculation and sporulation is known as the incubation period. This apparently varies somewhat with different species but the normal range for the uredo as reported by a number of authors lies between eight and twelve days. Marshall Ward has noted that the normal incubation period is shortened during clear sunny weather and Iwanoff (**16**) found that shading delayed aecidium-formation in *P. graminis*.

What stimulus, or stimuli, determine the entrance of the germ tube into the stomata of the leaf has not been established. It is perhaps most generally held that the host exerts a chemical influence on the germ tube. If this is true it is apparently not a specific influence, since germ tubes have been shown to enter the stomata of quite the wrong host. Massee (**22**) endeavored to demonstrate a positive chemotropism but was unable to eliminate the effects of hydrotropism from the experiment. Marshall Ward (**37**) has noted an apparent heliotropic curvature in the germ tubes of *P. dispersa*. Balls (**1**) placed uredospores on a rubber film provided with small holes. Laboratory air was on one side of the film while the air on the other side was saturated with moisture at 23°. The germ tubes entered the holes and grew through into the region of higher pressure of water vapor. He believes that growth towards greater moisture will explain the entrance of the germ tube into the host.

A recent article by Melhus (**24**) on the culture of parasitic fungi deals with the culture of *P. Helianthi*, *P. coronata*, *P. graminis* and *P. Sorghi*. The methods employed by him consist in spraying the plants to be inoculated with a spore suspension, covering with a hood and placing in a refrigerator or humidity-box for twenty-four hours, at 14° for *P. Helianthi*, 16° for *P. coronata*, and 18° for *P. Sorghi*. He finds that *P. coronata* will not maintain itself even though supplied with plenty of host material. It is more

difficult to hold in culture than the sunflower rust, a fact which is attributed to the slower growth of the oat plants. Reinoculation is necessary about every three or four weeks. *P. Sorghi* is more easily cultured than the cereal rusts and Melhus has propagated it both winter and summer. The amount of infection increases as the corn plants grow larger and the fungus spreads from one culture to another by natural agencies.

I have tabulated the principal recorded observations on the influence of various conditions on spore germination and development in the rusts in TABLE I. These scattering and somewhat fragmentary records illustrate the incompleteness of our knowledge of rust physiology.

CULTURE METHODS

Preliminary experiments were made to determine how long single infections would maintain themselves under greenhouse conditions and whether they would self-propagate to any extent. The rusts used were *Puccinia dispersa* Erikss. on rye and *Puccinia coronifera* Kleb. on oats. The seedlings were grown in 5-inch pots and infections were secured by atomizing them with a uredospore suspension followed by covering with a bell jar for twenty-four hours. The incubation periods for both forms averaged about twelve days in this preliminary work. The infections secured maintained themselves for about two weeks after the first ripening of the pustules. After this time the number of pustules visibly decreased through withering and dying off of infected leaves and eventually the cultures became entirely free from infection. Close association of non-infected with infected plants did not produce new infections. No marked difference in susceptibility between old and young plants was apparent but the younger were found more desirable for inoculation because their greater compactness facilitated uniform covering with the spray.

My further experiments were planned to meet various requirements. First a method to maintain cultures of as nearly as possible constant virulence, with the fewest necessary transfers, over extended periods of time, was tested out. Such a method is suited, for example, to test the possibility of maintaining the rust for long periods in the uredo stage and for the study of the effects of such conditions of growth on its virulence, incubation period,

TABLE I

Species of rust	Spore form	Author	Conditions influencing spore germination and development: Temperature Min.	Temperature Opt.	Temperature Max.	Moisture	Chemicals* Inhibiting	Host extracts	Host	Storage	Variation in light	Length of incubation period
Puccinia graminis	II	DeBary				+ after 2–3 hours in water	%			1–2 months		8 days
Puccinia graminis	I	DeBary					1. KNO_3 0.5 Na_2CO_3 0.1 $C_2H_2O_4$ 0.1 $C_2H_4O_2$			1 month		
Puccinia graminis	II	Wüthrich	20–21°			+ after 15 hours	0.1 H_2SO_4 0.1 HCl					
Puccinia graminis	I	Iwanoff					0.1 $FeSO_4$ 0.01 $ZnSO_4$ 0.01 $ZnCl_2$ 0.01 $CuSO_4$ 0.001 $HgCl_2$				Shading lengthens incubation period	
Puccinia graminis	II	Pole Evans				Dry weather favors development						
Puccinia graminis	II	Eriksson	Low temperatures accelerate			"Capricious"						
Puc inia coronata	II	Eriksson	Low temperatures accelerate			"Capricious"						
Puccinia glumarum	II	Eriksson	Low temperatures accelerate			"Capricious"	0.01 H_2SO_4 0.01 $FeSO_4$ 0.001 $ZnSO_4$					

*All data as to chemicals are Wüthrick's.

TABLE I—*Continued*

Species of rust	Spore form	Author	Conditions influencing spore germination and development										Length of incubation period
			Temperature			Moisture	Chemicals		Host extracts	Host	Storage	Variation in light	
			Min.	Opt.	Max.		Favoring	Inhibiting					
Puccinia graminis	I	Wüthrich	.....	.....	.....	.....	0.001 $CuSO_4$ 0.0001 $HgCl_2$		.....	.....	.....	.....	.....
Puccinia graminis	II	Johnson	2°	12–17°	31°	.....	.....		.....	.....	.....	.....	.....
Puccinia coronata	II	Johnson	7–8°	12–17°	30°	.....	.....		.....	.....	.....	.....	.....
Puccinia rubigo-vera	II	Johnson	2°	12–17°	30°	.....	.....		.....	.....	.....	.....	.....
Puccinia rubigo-vera	II	Carleton	.....			.....	Na K	Hg Cu	.....	.....	.....	.....	.....
Puccinia graminis	II	Carleton	.....			.....	Mg S	Fe Pb	.....	.....	.....	.....	.....
Puccinia coronata	II	Carleton	.....			.....	Ca NH_3	Cr Alkaloids	.....	.....	.....	.....	.....
Puccinia coronata	II	Melhus	16°			.....	.....	.....	.....	.....	.....	.....	8–12 days
Puccinia Helianthi	II	Melhus	14°			.....	.....	.....	.....	.....	.....	.....	10 days
Puccinia Sorghi	II	Melhus	18°			.....	.....	.....	.....	.....	.....	.....	8 days
Puccinia rubigo-vera	II	Plowright	+ after exposure to − 5° in open			.....	.....	.....	.....	.....	.....	.....	.....
Puccinia rubigo-vera	II	Bolley	.....	.....	.....	.....	.....	.....	.....	.....	30 days in open	.....	.....
Puccinia dispersa	II	Marshall Ward	10–12°	20°	26–27°	.....	.....	CO_2	No influence	.....	61 days	+ in dark and in red or blue light	7–10 days
Puccinia dispersa	II	Freeman	.....	.....	.....	Often poor in water	.....	.....	.....	Good	.....	.....	.....
Puccinia Asparagi	I, II	Smith	.....	.....	.....	Dew essential for infection	.....	.....	.....	.....	.....	.....	.....

TABLE I—*Continued*

Species of rust	Spore form	Author	Conditions influencing spore germination and development										Length of incubation period
			Temperature			Moisture	Chemicals		Host extracts	Host	Storage	Variation in light	
			Min.	Opt.	Max.		Favoring	Inhibiting					
Phragmidium Rosae-alpinae	I	Gibson	.....	.....	.....	.....	.....	.....	.....	Germ tubes enter wrong host	82 days	.....	.....
Puccinia Chrysanthemi....	II	Gibson	6–6.5°	21–25°	25–30°	.....	.....	.....	.....	.....	71 days	.....	.....
Puccinia Chrysanthemi....	II	Jacky	+ after exposure to − 25° in open			.....	.....	.....	.....	.....	.....	.....	.....
Phragmidium obtusum....	II	Dietel	+ after breaking out of ice and snow			.....	.....	.....	.....	.....	.....	.....	.....
Peridermium Strobi.....	I	Klebahn	.....			Weak in water	.....	.....	Fair	A-bundant	5 weeks	.....	.....
Peridermium Soraueri....	I	Klebahn	.....			.....	.....	.....	.....	.....	20 days	.....	.....
Coleosporium Senecionis...	I	Sappin-Trouffy	.....			Poor or none in water	.....	.....	A-bundant	.....	.....	.....	.....
Uromyces Pisi.....	I	Tischler	Host outgrows rust in moist air at 25–27°			.....	.....	.....	.....	.....	.....	.....	.....
Uredo Bupleuri.....	II	Barclay	.....			.....	.....	.....	.....	.....	8 mo. 12 d.	.....	.....
Uredo Gomphrenatis.....	II	Barclay	.....			.....	.....	.....	.....	.....	7 mo. 7 d.	.....	.....
Puccinia Prenanthis.....	.....	Barclay	.....			.....	.....	.....	.....	.....	7 mo. 6 d.	.....	.....
Puccinia Caricis-filicinae..	.....	Barclay	.....			.....	.....	.....	.....	.....	5 mo. 12 d.	.....	.....
Uromyces Vossiae.....	II	Barclay	.....			.....	.....	.....	.....	.....	5 mo.	.....	.....
Puccinia Acetosae.....	.....	Barclay	.....			.....	.....	.....	.....	.....	3 mo. 17 d.	.....	.....
Uromyces Pisi.....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 15 d.	.....	.....
Melampsora Lini.....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 15 d.	.....	.....
Puccinia flosculosorum....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 7 d.	.....	.....

etc. It was found that it was necessary to transfer the infection to new cultures once a month. Five ripe, oval pustules were selected for each inoculation. The spores from these were removed with a scalpel and immersed in 25 c.c. of water in the bottle of the atomizer. This was then shaken vigorously to secure uniform distribution of the spores before application and the culture was subsequently covered with a bell jar for twenty-four hours. "Spring" rye and "Kherson" oats were used exclusively. About twenty-five seeds were sown to a 5-inch pot.

Six transfers at intervals of a month were made. At first seed for the next culture were sown two weeks prior to the date set for transfer, but a further simplification of method was secured by sowing a month prior to inoculation. Thus sowing and transfer could be made at the same time. Plants were a month old when inoculated and two months old when abandoned.

Well-infected cultures on both oats and rye were maintained for six months in this way. No attempts were made to measure exactly the degree of infection secured but the pustules were seemingly as numerous at the end of the period as at the beginning. Germination tests of spores in drop cultures made at various times gave 50–75 per cent. germination in six to twelve hours. The incubation periods during the six months were quite uniform. Twelve days was the longest incubation period recorded and ten days the shortest.

Cultures made in this way show relatively few sori. The method provides for maintenance of a rust culture but it does not provide an abundant supply of infected plants at all times. During the incubation period the pustules have disappeared from the old cultures and have not matured on the new ones. To have abundantly infected plants continuously available the following method was used. Transfers were made once a week instead of once a month. Since two weeks were required for complete ripening of the pustules it was necessary to run alternate series of host cultures. One series was ready for transfer one week and the other series the week following. Seeds for subsequent cultures of each series were sown at the time of inoculation and the seedlings were thus two weeks old when the rust was transferred to them. Cultures of *P. coronifera* have been maintained for eight months

by this method and the fungus has gone through thirty-seven generations of the uredo stage with no decrease in virulence.

It was soon found that even more simple methods of inoculation are equally if not more efficacious than the application of spore suspensions with an atomizer. The plants to be inoculated are first thoroughly atomized with water. A well-infected culture pot bearing fully ripe pustules is then held in a horizontal position immediately above them and given a vigorous shaking. The spores that fall from above are caught in the small drops of water provided by the spray. If the culture used is heavily infected the falling spores may be seen as yellow clouds. The inoculated plants are then covered for twenty-four hours. Four pots of seedlings can be inoculated simultaneously from the same culture and a uniform degree of infection secured on all four by placing them close together and holding the culture somewhat higher than for inoculating a single pot. It was found that spraying prior to inoculation could be dispensed with but the pustules secured were somewhat less numerous than when the spray was applied. To secure the best results the culture used for transfer must be heavily infected and the transfer made shortly after the ripening of the pustules. If transfer is delayed more than a week after sporulation begins, inoculation with a spore suspension must be resorted to.

Very numerous and uniformly distributed pustules were secured and maintained by this dry-spore method of inoculation. The approximate number of pustules per plant in a culture was determined in the following way.

For facility in counting the surface area of the pot it was divided into smaller areas with strips of cardboard. The number of plants and infected parts on each of the smaller areas was then easily ascertained. Ten plants were then taken at random from the culture, removed to the stage of a binocular, and the number of pustules on the infected parts determined. TABLE II shows the amount of infection on a typical culture. In this culture all of the first leaves were infected, 62.5 per cent of the second leaves, and 29.1 per cent of the sheaths. The average number of pustules on the first leaves of the ten selected plants was 574.4, on the second leaves, 22.9, and on the sheaths, 1.4. The small number of

pustules on the second leaves was due to the fact that only their tips were exposed at the time of inoculation. The number of pustules on the upper and lower surfaces of a leaf is sometimes equal and two pustules are often situated directly opposite each other. The average number of pustules per plant maintained in the mass culture experiments was about 200–300. The lowest average recorded for a culture was 161.6, the largest 598.7. The largest number of pustules counted on a single plant was 996 (plant 3, TABLE II).

TABLE II.

ANALYSIS OF INFECTION ON CULTURE 7C

Treatment: Innoculated by dry spore method, covered with bell jar. Number of plants, 72. Date planted, January 1. Date innoculated, January 13. Date of sporulation, January 24.

Number of parts	Part of plants	No. of parts infected	Per cent. infected
72	First leaves	72	100
72	Second leaves	45	62.5
72	Leaf sheaths	21	29.1

NUMBER OF PUSTULES ON TEN PLANTS SELECTED AT RANDOM

No. of plant	First leaves		Second leaves		Leaf sheaths	Total, entire plants
	Lower surface	Upper surface	Lower surface	Upper surface		
1	297	246	27	30	1	601
2	215	341	12	21	5	594
3	506	441	18	31	0	996
4	444	521	7	11	3	986
5	234	336	4	5	0	579
6	225	249	0	0	0	474
7	376	403	10	13	3	805
8	99	140	0	0	2	241
9	53	115	1	3	0	172
10	189	314	14	22	0	539
Total....	2638	3106	93	136	14	5987
Ave.....	263.8	310.6	9.3	13.6	1.4	598.7
Ave.....	574.4		22.9		1.4	598.7

NORMAL DEVELOPMENT OF THE UREDOSORI OF P. CORONIFERA

The period of incubation for the rust in the open greenhouse varied between eight and eleven days from October to December. Twelve days was the constant incubation period during December but this decreased to nine days in the latter part of January and

remained at nine days throughout February and March. The sequence of stages during a nine days incubation period may be divided into two periods. First, a period of vegetative development during which no evidence of infection is seen. Second, a fruiting period during which the stages in the formation of the pustules are apparent. The first period occupies five days after inoculation and the first visible evidences of pustule formation become apparent on the sixth day. The leaves on this day have a faint mottled appearance which is due to the presence of small areas that are lighter in color than the surrounding leaf tissue. These areas are visible only by transmitted light. On the seventh day the light areas become more conspicuous and their boundaries more sharply defined. The areas become slightly swollen on the eighth day and a light orange color is apparent. During the next twenty-four hours the development of the pustules is rapid. They continue to swell until the epidermis of the leaf is ruptured by a longitudinal slit and the orange mass of spores is extruded. The mass of spores hangs together for a time but breaks apart on drying and falls from the leaf as separate spores or in small groups when the leaf is disturbed.

OBSERVATIONS ON CONDITIONS AFFECTING SPORE GERMINATION, INFECTION, AND RATE OF DEVELOPMENT

Effect of moisture

It has been demonstrated a number of times during this culture work that a humid atmosphere provided by covering with a bell jar is necessary to secure infection. Abundant moisture may be supplied at the time of inoculation and still the plants will not become infected, in the greenhouse, unless they are covered soon afterwards. The drops of water apparently dry up before germination and infection result. The per cent of saturation in the greenhouse in which my experiments were made as obtained from the hygrometer records, averages about 75–80 per cent with a temperature range between 55 per cent. and 85 per cent. Although the conidia of *Erysiphe graminis* infect the cereals spontaneously under these conditions, the uredospores of *P. coronifera* will not do so.

To test the possibility of providing conditions of humidity

under which the rust might become self-propagating by close association of cultures, a sash frame culture box, 3 ft. square, was made of five window sash. The humidity maintained here when cultures were growing in it was quite constant and averaged 93 per cent. with occasional fluctuations of 2–3 per cent. Even in such a humid atmosphere new infections occurred only sparingly, although cultures were sprayed and heavily inoculated. To obtain good infections it was necessary to cover the cultures with bell jars as in the open greenhouse.

A direct comparison of the effects of covering and not covering in the culture box was obtained by a statistical study. Two pots of seedlings, each seven days old, were inoculated simultaneously from the same culture, after which one was covered for twenty-four hours and the other was left uncovered in the culture box. During the remaining eight days of the incubation period they were exposed to equal conditions of humidity. The difference in the degree of infection obtained on the two cultures was marked. The average number of pustules per plant on the covered culture was 161.6 as compared with 10.4 on the non-covered. This would be but a 6 per cent infection on the non-covered culture if that obtained on the covered is regarded as the normal. The difference in the degree of humidity to which the cultures were exposed for twenty-four hours after inoculation could not have been more than 7 per cent, as the average in the culture box was 93 per cent and the atmosphere under the bell jar was presumably saturated. It is rather striking that this difference of 7 per cent should have produced a difference in degree of infection of 94 per cent. The spores that produced the 6 per cent normal infection on the non-covered culture probably germinated more rapidly or were more favorably located with reference to moisture than the bulk of the spores.

Effect of temperature

To test the effect of different temperatures on the degree and rate of development of *P. coronifera*, two cultures of the same age were inoculated simultaneously from the same stock culture. Immediately afterwards one was placed in the greenhouse "stove"

where the temperature ranges between 20° and 30°.* The temperature here was quite constant for each twenty-four hours throughout the experiment. It did not fall below 25° from 10 A.M. to 5 P.M. nor rise above 20° from midnight to 6 A.M. The other culture was placed in the greenhouse where the temperature fluctuation was between 14.5° and 21°. Here the temperature remained quite constant at 16° for the greater part of the twenty-four hours. It reached 21° for a short period at noon and 14.5° at midnight. Both cultures were covered after inoculation. The first visible signs of infection became apparent on the culture in the "stove" on the fourth day after inoculation and fully ripe pustules were produced on the seventh day. Evidences of infection did not become visible on the culture in the greenhouse until the seventh day after inoculation, which was the date of sporulation for the culture in the "stove," and ripe pustules were not formed until the twelfth day. The high temperature of the "stove," which was an average increase of about 7–8°, was apparently responsible for a marked increase in the rate of development of the fungus and a decrease of five days in the incubation period. No differences in the degree of infection secured on the two cultures were apparent. The experiment was repeated immediately, but without a control, and the incubation period for this culture in the "stove" was but six days. This is the shortest incubation period I have observed.

Further cultures gave results as follows. No. 7 in the "stove," incubation period seven days. The temperature for each day was 20° from 6 P.M. to 6 A.M. and 25–30° from 8 A.M. to 2 P.M. Three controls in the greenhouse, incubation period nine days. Temperature 10–15.5° from 6 P.M. to 6 A.M. and 15.5–21° from 9 A.M. to 5 P.M. No. 8 in the "stove," incubation period nine days. There were many minor fluctuations in this period. The maximum was 30°, the minimum 8°. The general range was distinctly lower than in the preceding test. Two controls in the greenhouse, incubation period twelve days. Temperature 10–15.5° from 6 P.M. to 6 A.M. and 15.5–21° from 10 A.M. to 3 P.M.

* The temperature records were obtained with Richard Frères' self-recording thermometers.

Effect of light

To determine the effect of light exclusion on spore germination and rate of development, four culture pots of the same age, seven days, were inoculated simultaneously. Immediately afterwards one of the four was transferred to a physiological dark room which joins the greenhouse. A continuous circulation of air between the two rooms is maintained by an electric fan. Thus the average degree of humidity of the dark room, which is about 80 per cent., does not fall below that of the greenhouse although the range of fluctuation, which is from 60 per cent. to 95 per cent., is somewhat greater. The other three cultures were placed in the culture box as controls. The culture was exposed in the dark room for three days and at the end of this time was returned to the culture box. The plants at this time were quite as green and fresh as those of the control cultures and could not be distinguished from them. The incubation period for the three controls was eight days, while that of the culture left three days in the dark room was eleven days. At the time of sporulation some of the leaves of this culture showed signs of yellowing at their tips. No pustules were produced on these discolored areas but on the normal green parts they were as numerous as on the controls. The difference of three days in the incubation periods is exactly equal to the period of light exclusion and indicates a complete arrest of the development of the fungus in the dark room.

The effect of light exclusion during the latter part of the incubation period was also tested. Four cultures were inoculated and placed in the culture box. Four days later one of them was transferred to the dark room, where it was left four days, and then returned to the culture box. No signs of infection were visible on it at this time, while the unripe pustules on the controls were plainly visible. The pustules on the controls ripened on the ninth day, while three additional days, twelve days in all, were necessary for a similar development of the culture that had been in the dark room. By excluding light four days in the latter part of the normal incubation period, the maturation of the rust had been delayed three days. This shows that even after the fungus has become well established in the host its development is strongly retarded in complete darkness.

The average difference in degree of humidity, of approximately 13 per cent, between the culture box and the dark room could not have been an important modifying factor in these results, as I have found that the incubation period is not modified by relative degrees of humidity after the first twenty-four hours. Thus parallel sets of cultures, when grown in the culture box and in the greenhouse under similar conditions of light and temperature but with the same difference in humidity that is found between the culture box and the dark room, had the same incubation period. Likewise when a culture was kept under a bell jar during the entire incubation period, with occasional removal for change of air, there was no difference between its incubation period and that of the control in the greenhouse that was covered for the first twenty-four hours only.

The question naturally arises how this retardation of the growth of the fungus is brought about. It may be the direct effect of total absence of light on the fungus itself. Then, again, it is possible that the fungus simply suffers from lack of food, since the host is incapable of assimilation in the darkness. It seems hardly possible, however, that such a complete inhibition in the growth of the fungus should have resulted in the brief time involved unless it is dependent on the transition products in photosynthesis. This latter possibility is by no means inconceivable and should this explanation prove the correct one it could be made the basis for an explanation of the obligate parasitism of the rusts and their inability to develop on any form of artificial medium.

VIABLE PERIOD OF UREDOSPORES

Two series of tests were made to determine the period through which the uredospores of *P. coronifera* would retain their vitality. Ripe spores were removed from pustules on the cultures and placed in small gelatine capsules which were then stored in the laboratory at room temperature. The first set of spores was stored on March 13. A drop culture made on this date gave a high per cent of germination in twelve hours. Drop cultures of the stored spores were made on March 19, 23, and 28 and April 12 and 30. From 9 to 16 per cent. of the spores sown germinated in each of these tests. No further trials were made until June 1 and at this time

the spores were colorless and failed to germinate. The last germination obtained was after 48 days of storage and the spores had lost their capacity for germination at some time between 48 and 80 days.

Another lot of spores were stored on November 26. These germinated in gradually decreasing per cents on January 8, 18, and February 2, 11, 18. The length of time required for the development of a germination tube increased from a period of 6–12 hours in November to a period of 36–48 hours in February. In the last drop culture made, on February 18, only 29 spores of 1,013 tested germinated. These few spores, about 0.2 per cent, had germinated after 84 days storage.

CONTROL OF MILDEW

The powdery mildew, *Erysiphe graminis*, became so abundant on the oats cultures that measures for its control became necessary. The mildew spreads rapidly in the greenhouse and outgrows the rust to such an extent that rust culture work may be seriously interfered with. Attempts at exclusion of the mildew by isolation of the cultures and inoculation with uredospores selected from apparently non-mildewed leaves proved unavailing.

The control and total exclusion of the mildew was achieved by treatment with sulphur dust. This was applied with a powder gun, twenty-four hours after rust inoculation. The plants were also atomized with a weak solution of sulphuric acid (1/1000) prior to the application of sulphur and were covered afterwards for twenty-four hours. With this treatment no mildew developed while control cultures became heavily infected.

This work was undertaken at the suggestion of Prof. R. A. Harper, to whom I am indebted for suggestions and criticisms.

SUMMARY

1. Two of the cereal rusts, *Puccinia dispersa* Erikss., on rye, and *P. coronifera* Kleb., on oats, have been cultured in the uredo stage, on the living hosts in the greenhouse, for a consecutive period of six months, from December 1912 to June 1913, by the transfer of infection once a month. *P. coronifera* was also cultured for a period of eight months, from September 1912 to May 1913,

with transfer of infection once a week. During this period the rust went through 37 generations of the uredo stage. No decrease in the degree of infection secured resulted from such continuous culture.

2. The average degree of infection maintained in mass cultures was approximately 200 pustules per plant. The largest number of pustules counted on an individual plant was 996.

3. *P. coronifera* does not self-propagate to any extent even when abundant host material is supplied and a constant humidity of 93 per cent is maintained.

4. High humidity is the essential factor in securing successful inoculation with uredospores of *P. coronifera*. No infections resulted when cultures were exposed in an atmosphere of 75 to 80 per cent of humidity, and at 93 per cent only 6 per cent of the normal degree of infection was obtained. Normal infections were secured only when cultures were covered with a bell jar for twenty-four hours subsequent to the application of spores.

5. The rate of development of *P. coronifera* increased with temperature increase. A decrease in the normal incubation period of five days, or 41 per cent, was produced in the "stove" where the temperature ranged from 20° to 30° while the range at which the normal cultures were grown was 14.5° to 21°.

6. Total light exclusion either early or late in the incubation period checks the development of *P. coronifera* and results in an almost complete cessation of growth.

7. Uredospores of *P. coronifera* when stored at room temperature gradually lose their capacity for germination. A 0.2 per cent germination was obtained after storage of eighty-four days.

COLUMBIA UNIVERSITY, NEW YORK.

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INDEX TO AMERICAN BOTANICAL LITERATURE

(1910–1913)

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Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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